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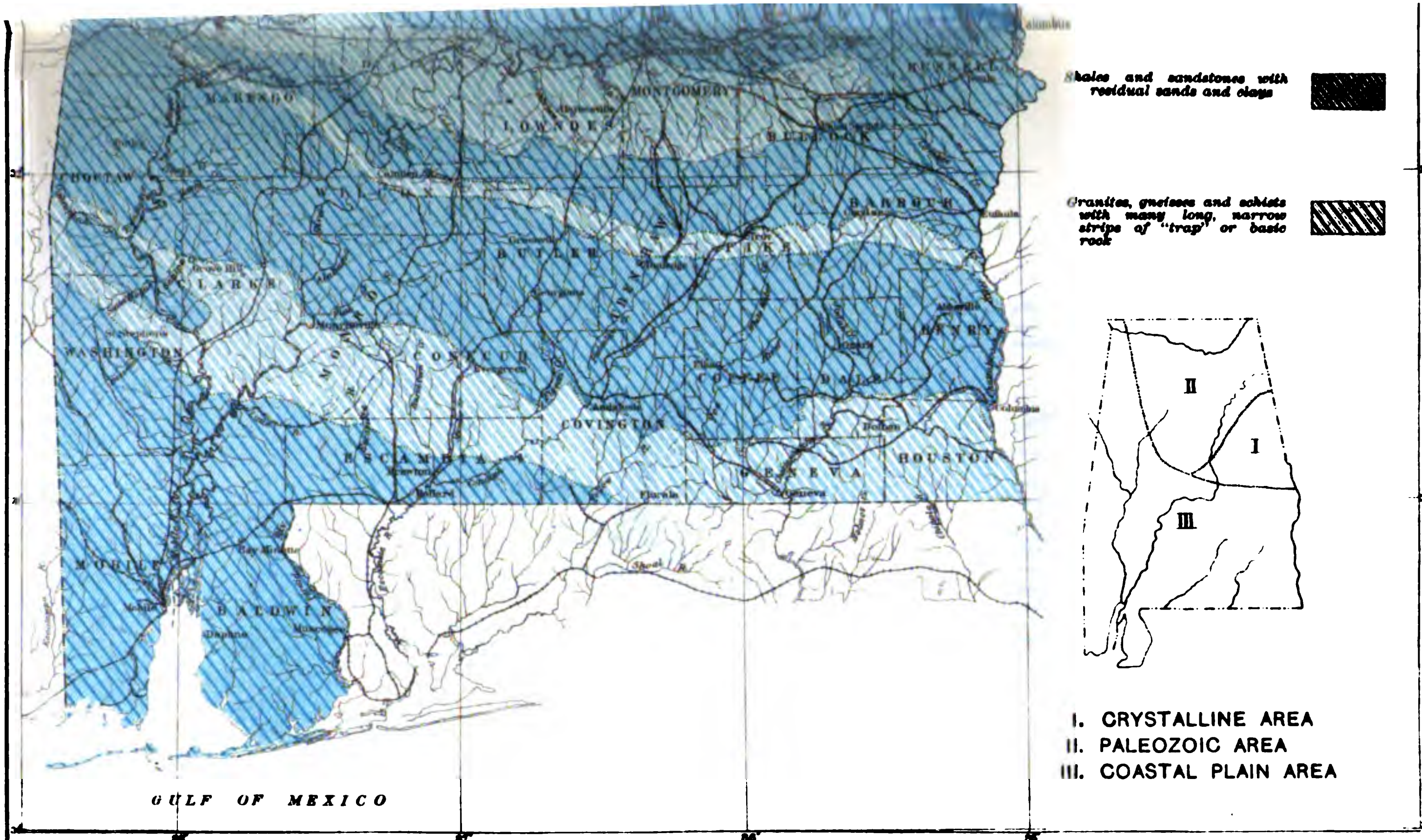
Shales and sandstones with residual sands and clays
Granites, gneisses and schists with many long, narrow strips of "trap" or basic rock
I. CRYSTALLINE AREA
II. PALEOZOIC AREA
III. COASTAL PLAIN AREA
I
II
III
GULF OF MEXICO
MARENGO
LOWNDES
MONTGOMERY
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CHOCTAW
BARBOUR
BUTLER
PIKE
CLARKE
HENRY
WASHINGTON
CONECUH
COFFEE
DALE
COVINGTON
ESCAMBIA
GENEVA
HOUSTON
MOBILE
BALDWIN
88°
87°
86°
85°

GEOLOGICAL SURVEY OF ALABAMA

EUGENE ALLEN SMITH, Ph. D., State Geologist

BULLETIN No. 11

Roads and Road Materials of Alabama

By

Wm. F. PROUTY, Ph. D.

Chief Assistant

MONTGOMERY, ALABAMA

THE BROWN PRINTING COMPANY, PRINTERS AND BINDER

1911

University, Ala., July 10, 1911.

HON. EMMET O'NEAL,

Governor of Alabama,

Montgomery, Alabama.

Sir:—

I have the honor respectfully to transmit herewith a report on Roads and Road Materials in Alabama by Dr. William F. Prouty, Chief Assistant, with the recommendation that it be published as Bulletin No. 11 of the Alabama Geological Survey.

Very respectfully yours,

EUGENE A. SMITH,

State Geologist.

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PREFACE.

Every publication should justify its being by some good return to those who take the time to look through its pages. The purpose of this bulletin is to stimulate an interest in the building of good roads and to serve as a guide to those who are actually engaged in the construction or maintenance of roads. In the compilation of the various articles from different authors, it has been the purpose to keep the volume as far as possible of a practical nature. The appendix contains information of various kinds which it is thought will be the most helpful to those using the volume.

Due to limited space the subjects treated are necessarily not exhaustive in their character, but they will be found to give the general principles and will serve as general guides. It may be noted that the articles deal with the country and suburban highways rather than city streets, for it is upon the former class of roads that the largest amount of money is spent, and the poorest results obtained. Most towns and large cities have skilled overseers and engineers to have charge of construction and maintenance work. It is evident throughout all the discussions in the bulletin that one of the greatest needs in the construction of good roads is competent engineers to have charge of the work. It is further evident that such engineers would save thousands of dollars to the tax payers and at the same time would give us far better roads.

One of the greatest drawbacks to good roads, in spite of all that has been said against it in recent years, is the perpetuation in many places of the statute labor system. In the election of commissioners and overseers it often happens also that popularity and political pull are too often the ruling factors rather than real fitness.

The Office of Public Roads at Washington and many of the leading universities of the country are now offering Road Engineering courses, and I wish to suggest that this branch of engineering offers exceptionally fine opportunities at the pres-

ent time, to such young men as will fit themselves thoroughly in it.

The creation of the State Highway Commission marks a new era in the progress of Alabama. It is to be expected that from now on economical methods of road construction and maintenance will be much more rapidly adopted, and it is to be hoped that the results of the investigation of the Commission in regard to materials and methods, which will be published from time to time, may prove of some real benefit to the public.

In the preparation of this volume we are greatly indebted to the contributors who have furnished free of cost the articles on the various subjects. We are also indebted to the U. S. Office of Public Roads for considerable information furnished and for co-operative work in compiling the statistical table. We are further under obligation to the various county officers of the State for furnishing statistics concerning their respective counties.

The book has been carefully indexed so that the contents may be made accessible with the least trouble.

ALABAMA ROADS AND HIGHWAYS—AN HISTORICAL INTRODUCTION.

By Dr. Thomas M. Owen, LL. D.

Director of the Alabama State Department of Archives and History, Montgomery, Alabama.

The sketch which follows is an effort, in a very brief way, to indicate the historic origin of Alabama roads and highways. Beginning with an account of aboriginal life, the main Indian highways and trails are discussed, followed by a description of the planting of white settlement, pioneer road beginnings, and early territorial and State road extension. The genesis of the present road laws concludes the introduction.

Within the limitations of a preliminary sketch, it is not to be expected that more than a brief outline can be given. While this is true, the facts and conclusions may be relied upon as accurate. In a way the details set forth will form a suggestive basis for more exhaustive and detailed treatment for the future.

Aboriginal Life.

The early explorers of aboriginal America in their ever continuous marches from the seaboard into the interior soon realized that this vast region was not a pathless wilderness. They found the Indians living in villages, subsisting mainly by agriculture, hunting and fishing being only secondary employments to supplement their main food supplies of corn, beans, pumpkins and squashes.

They found the villages, whether contiguous or far apart, connected by trails, and these trails were used by the explorers themselves in their expeditions. In process of time, in the progress of exploration, it was found that Indian America was, in fact, a vast network of such trails, connecting not only village with village of the same tribe, but extending far off to

other tribes, so that it was feasible by means of these trails to traverse the entire continent. The trails were always along lines where there were the fewest physical obstacles or obstructions, often going along on the watershed of two streams, when these watersheds pointed in the right direction. The crossing places of streams were always selected with such judgment that from the most remote period down to the present day, these same crossing places have served in numerous instances the purpose of man, whether savage or civilized. The trails also often formed the basis of the modern civilized or white man's road.

The intertribal trails served all the purposes of war and peace. War parties marched along them in their raids against other tribes, in quest of booty and scalps. In times of peace the Indian trafficker slowly toiled along over them laden with his wares to exchange for the wares of another tribe. These intertribal trails thus strongly appeal to the archaeologist, as they were means of a dissemination of relics, which show the wide extent of Indian intertribal traffic.

Relics of Mica have been found in Atlantic States that must have come from a far western region. Sea shells that can only come from the Gulf of Mexico have been found in Ohio mounds. Obsidian relics have been found in Alabama that can only be referred to the Yellowstone region. Relics too of shell have been found in Alabama that show an undoubted intercourse with the prehistoric Shawnees of Cumberland River in Tennessee. White quartz arrow points have been found on a village site in Mississippi that certainly came by tribal traffic from the Indians of Alabama.

An account will now be given of some of the Indian trails of Alabama, the facts given, assembled from acient maps, from ancient books, and from pioneer traditions. This account from the very nature of things is necessarily imperfect, as there can be no doubt that there were numerous other trails, not recorded on maps and in books and not preserved in border tradition. Still the ones that are given will serve to show that the red man of Alabama had a wide intercourse, not only within the bounds of his own tribe, but like the Greek

Ulysses of old, he was often a much traveled man, even in the far distant tribes of the East, North, and West.

Some Indian Highways and Trails.

The Great Southern Trading and Migration Trail led from the mouth of St. John's River, Florida, to the mouth of Red River in Louisiana. It crossed the Apalachicola River just below the confluence of the Chattahoochie and Flint, and the Mobile River a few miles above Mobile. It is intimately associated with Mobile Colonial history. Apart from its association with war and traffic, it was the great migration trail used by the Southern Indian tribes and sub-tribes that settled in Louisiana after the fall of French dominion in Mobile.

A trail branched from the great migration trail at the Apalachicola crossing and ran northwest to the Alibamo towns. This trail was the great route of intercommunication between the Creeks and the Seminoles.

A continuation of the Apalachicola-Alibamo trail ran from the lower Coosada towns northwesterly by way of Oo-e-asa to Buttahatchee River and thence continued to the Chickasaw Nation. A Chickasaw Indian traveling this trail would have no difficulty in going to the Coosada and Alibamo towns, and thence to the mouth of St. John's River in Florida.

The Great Pensacola Trading Path, known in pioneer days as the wolf trail, was the most noted trail in Alabama. It led from the Alibamo towns, a group of villages occupying the site of Montgomery, down to Pensacola, and was much used by the Creek Indians, and the traders. By the latter it was enlarged into a horse path, and afterwards it became an American road, much of which is still used. The battle of Burnt Corn occurred on this trail. The present railroad from Montgomery to Pensacola follows closely the lines of the old trail.

A western branch of this trail deflected at Bluff Springs in Escambia county, Florida, and ran northwesterly to the junction of the Alabama and Tombigbee Rivers.

The Mobile Tuckabatchie Trading Path crossed the wolf trail at Flomaton, passed through Brewton, continuing for

some distance on the divide between Persimmon and Pigeon Creeks, crossing the latter creek about eight miles southeast of Greenville and thence on to its terminus at Tuckabatchie. The railroad from Mobile to Brewton follows closely the line of the old trading path.

The Big Trading Path, from Mobile to the Choctaw and Chickasaw Nations, ran about a mile west of Citronelle, thence by Isney in Choctaw county and on to Coosha town in Lauderdale county, Mississippi, thence to Plymouth in Lowndes county, Mississippi, thence to the Chickasaw towns. Much of the trading path, then an Indian trail, was traveled by Henri de Tonti in 1702. In American times it became a horse path for traders, afterwards the greater part was used as a post road by the government, and eventually a large part of it was converted into what was known as the Tennessee road.

The Alamuchee-Creek Trail crossed the Tombigbee at the shoals a short distance above the influx of Chickasawbogue in Marengo county. According to local tradition this trail, trending easterly, crossed the Alabama River just below the influx of Cahaba, thence to old Town Creek and thence to the Alibamo towns, the site of modern Montgomery. The part of the trail leading from Montgomery to old Town Creek was certainly the trail traveled by De Soto, and in more recent times a part of the trail formed the basis of the American road leading from Linden to Adams and Martins.

The Great Tombigbee War Crossing was at Black Bluff, Socteloosa, about two miles below the influx of Sukinatcha. Several trails from the Choctaw country converged at this crossing and then continuing as one trail for some distance to the east of the river, where the trail forked, one branch leading to Okfuskee on the Tallapoosa and the other to Coosada on the Alabama. This crossing was greatly used by the Creeks and Choctaws in their wars.

After the surrender of Fort Toulouse, large numbers of Coosadas (Coshattees) and Alibamos settled at Black Bluff, and for some distance thence down the river. At the outbreak of the Creek-Choctaw war of 1766 these Tombigbee

settlers received such rough treatment from both belligerents that they returned to their former homes on the Alabama.

The Great Savannah-Mississippi River Trail led from Savannah up to the northern part of Effingham county, thence went west to Tuckabatchie, thence continuing its course to its terminus at Milliken's Bend on the Mississippi—a trail equal in length to the Great Southern Migration Trail.

Two great trails from the east united at Flat Rock in Franklin county, Alabama, and thence continued west to the Chickasaw Nation. One or these trails came from the Chattahoochie to Little Okfuskee thence to Flat Rock. The other, the High Town trail, started from Tellico in Monroe county, East Tennessee, thence southwest to Coosa town, and from it to Flat Rock.

The Great Cumberland River War trail led from the Hickory Ground up the east side of Coosa River up to Turkey town, thence to the well-known Creek crossing on the Tennessee River, near the mouth of Town Creek, above Guntersville, thence to the Cumberland settlements in Tennessee. There were three other crossings on the Tennessee River, one at Guntersville, one two miles below it, and one at Ditto's Landing. But the one near the mouth of Town Creek was the most noted and most used by war parties in their raids against the Cumberland Settlements.

A trail led northwardly from the Coshattee towns and united with the Cumberland war trail in Marshall county. This was the trail used by the Coshattee war parties.

A trail led from Will's Town, a Cherokee town, and united with the Cumberland war trail at the Creek crossing.

A trail led from the Creek crossing on the Tennessee to Nickajack, thence the trail continued to Tellico Blockhouse. That part of the trail from the Creek crossing to Larkins Landing in Jackson county was afterwards a public road and was the first mail route established in Marshall county.

The Great Charleston-Chickasaw Trail crossed Savannah River at Augusta, whence the trail ran to Okfuskee in the upper Creek country. From this town it ran to Coosa, thence to Squaw shoals on the Black Warrior, thence to the old Chick-

asaw crossing at Cotton Gin. It was first traveled by Col. Welsh in 1698, and afterwards used by the English traders. At the crossing on the Chattahoochie a branch of the trail ran to the Alibamo towns.

White Settlement; Pioneer Road Beginnings; and Early Territorial and State Road Extension.

The foregoing presents in brief, but in as accurate and complete form as in short compass can now be done, the highways of the Southern Indian country about 1775. It was with conditions of land travel and transportation as here indicated that the Colonial and Provincial trade had been carried on about one hundred years, and with these and slowly changing conditions that the settlement of this vast area was to go on for the next quarter of a century.

At the outbreak of the American Revolution in 1776 there was not a white settlement within the limits of the present States of Alabama and Mississippi, and in West Florida, save at Mobile, Natchez and Pensacola. Here and there, however, throughout this vast territory were occasional white settlers, usually traders or trappers, but their stay in any one locality was never permanent. During the progress of hostilities between the colonies and Great Britain, and immediately following its close, from time to time, small portions of refugees from Georgia, and the Carolinas, drifted into what was vaguely known as the Georgia Western Country, and located themselves in the Alabama-Tombigbee basin. Their actual settlements were in the present Clarke, Baldwin and Washington counties. In Pickett's Alabama is an interesting picture of these first settlements.

The close of the Revolution found the number increasing, and the Spaniards encouraged further immigration. The Choctaw Indians had in 1765 ceded a tract of land West of the Mobile River and extending North to the Sintabogue in the present Washington county. Grants of lands in this cession were made, and later, cessions were made indiscriminate-

ly in the delta country, now in the vicinity of Mt. Vernon and twenty miles north and several miles east and west.

By 1798 when the Mississippi Territory was formed, these settlements had expanded until there were several hundred souls in the Tombigbee country. The social, economic and political affairs of these people demanded regulation, and on June 4, 1800, Washington county was laid out by executive proclamation. It embraced practically all of the present South Alabama, north of line 31 degrees.

Contemporaneously with the growth of these settlements in the heart of the present Alabama, was the general growth of what is historically known as the Old South-West, perhaps the most remarkable and facinating period in the annals of American settlement. From the Atlantic seaboard the pressure of population westward found its way into the Northwest, the present states of Kentucky and Tennessee, and down the Mississippi River to the Natchez country.

The migration into the Alabama section of the Mississippi territory moved rapidly until checked by the Creek War of 1813-14. Up to that time five counties had been formed. The short, sharp and swift series of campaigns under Jackson, Coffee, Floyd, and Claiborne ending with the battle of the Horse Shoe Bend March 27, 1814, broke the Creek power, and within the next five years more than one hundred thousand people had located in Alabama. The Alabama Territory had been formed March 3, 1817, and Dec. 14, 1819, a joint resolution was adopted admitting the State into the Federal Union.

The coming of the pioneers, their settlement in groups here and there throughout those parts of the State then open to immigrants, and the formation of towns, all affected directly the location and opening up of permanent roads, but at the same time the early Indian trails and the government roads had themselves in a measure shaped and directed the trend of settlement.

The evolution therefore of the pioneer road from the old Indian trails, paths and trade routes was not only an easy, but a natural process. The coming of the white settlers was along these highways, if they could be so dignified. Some came,

however, by the river routes. Another very natural condition was the planting of little settlements along or near the trails. At first there were no vehicles, but with the larger movements of immigrants and the coming of the wealthier class, the rolling hogshead, the gig and the wagon were employed. The widening of the trails, the selection of new routes, the erection of ferries, the laying of causeways and the opening of houses of entertainment followed.

Twenty-two counties were in existence when the Constitution was adopted in 1819. The Legislatures of 1819, 1820 and 1821 created ten more. These represented more or less contiguous groups of settlements, while at the same time their boundaries were in part determined by physical conditions. County seats were located largely from reasons of convenience to the people, both as regards streams and roads. The latter therefore both determined and were determined by town locations.

Some of these highways will now be described.

NATCHEZ TRACE.

The oldest of these is what is known in Southern history as the Natchez Trace, or the Great Columbian Highway. Its Northern terminus was Nashville, Tennessee; its Southern, Natchez, Mississippi Territory. It was not only the earliest of the highways projected by the Federal government in anticipation of and as a part of its policy of opening up the lower Mississippi and the Old Southwest, but it is to be compared with the old Federal Road only in historic importance. Its route was southwest, passing the present towns of Franklin and Columbia, Tenn., and crossing the Tennessee River a few miles below Mussel Shoals at Colbert's Ferry. The authorization of the road is to be found in treaties with the Chickasaws and Choctaws dated October 24, 1801, and Dec. 17, 1801, respectively. This road constituted the first post route in the Southern country. It entered Alabama in the northern part of Lauderdale county, crossed the Tennessee River at Colbert's Ferry, and passed through the northwest section of the present Colbert (formerly Franklin) county.

OLD FEDERAL ROAD.

The second of the highways in the Gulf country to receive Federal recognition was what is historically known as the Old Federal Road. Originally an Indian trail, by treaty with the Creeks, Nov. 14, 1805, it was formally recognized as "a horse-path through the Creek county, from the Ocmulgee to the Mobile." By 1811 it had expanded to the other with emigrants from the western part of the territory.

It was the great highway from the South Atlantic seaboard and the interior of Georgia to the whole of South Alabama and South Mississippi. Its influence was far-reaching. In historic importance it is rivalled only by the Natchez Trace. For Alabama history proper it must take first rank. It survives and is in part still used. It entered the State at or near Fort Mitchell in Russell county, and passed in part through the present counties of Russell, Macon, Montgomery, Lowndes and Butler, formed a part of the boundary line between Monroe and Conecuh counties, and continued through Baldwin and Washington counties. Along its route in early days were located Fort Mitchell, Russell county, Fort Bainbridge and Fort Hull, Macon county, Mt. Meigs, Montgomery county, Fort Dale, Butler county, and Fort Montgomery in Baldwin county. Over it traveled Lorenzo Dow and wife, Peggy Dow, Vice-President Aaron Burr, Gen. LaFayette and other celebrities. About 1807, it was extended westwardly from Old St. Stephens to Natchez.

GEN. JACKSON'S OLD MILITARY ROAD.

The Tennessee terminus of this road was the town of Columbia, where it united with or branched from the Natchez Trace. It ran southwest and a few miles east of the Natchez Trace, entering Alabama in the northern part of Lauderdale county and crossing the Tennessee River at Florence. It continued southwest through Tuscumbia, Colbert (formerly Franklin) county, Russellville, Franklin county (where it crossed the Gaines Road or Trace), old Pikeville, Marion county, Sulli-

gent (old Moscow), Lamar (then Marion) county, to Columbus, Miss.

The date and circumstances of its projection and opening are obscure. It had evidently been opened up, in part at least, prior to April 27, 1816, on which date Congress made an appropriation "for the purpose of repairing and keeping in repair the road between Columbia, on Duck River, in the State of Tennessee, and Madisonville, in the State of Louisiana, by the Choctaw agency." Government work under this authorization and subsequent orders of the War Department began in June 1817. The work was completed in January, 1820.

GAINES' ROAD, OR TRACE.

This road extended from Melton's Bluff, at the head of Elk River shoals, on the South band of the Tennessee River, in Lawrence county, to Cotton Gin Fort, on the Tombigbee River. It passed through Courtland, Lawrence county, near LaGrange, Colbert (then Franklin) county, and Russellville, Franklin county, where it crossed Gen. Jackson's Old Military Road. Under the treaty with the Chickasaws of Sept. 26, 1816, it became the eastern boundary of that tribe. It was originally a horsepath used for bringing merchandise from the Tennessee River to the Tombigbee River, whence it was carried by boats to the Indian trading house at St. Stephens.

PENSACOLA AND FORT MITCHELL ROAD.

In the months of June, July and August, 1824, a road, 233 miles in length was constructed from Pensacola, Fla., to Fort Mitchell, Ala. It extended northeast through Covington, Pike, Barbour and Russell counties, probably passing old Montezuma, and Troy. The work of opening up this road seems to have been done under the direction of Capt. D. E. Burch, an Assistant Quartermaster, U. S. Army.

OTHER ROADS.

The necessary multiplication of new roads and the absence of trustworthy early maps makes unsatisfactory any attempt

at even a partial list. From the great crossing places on the Tennessee, the Chattahoochee, the Alabama and the Tombigbee Rivers radiated many roads, extending into every section of the State. Tuscumbia, Elyton, Tuscaloosa, Montgomery, old Montezuma (Covington county), Greensboro, Russellville, Demopolis, and other points were important road centres. And long before the removal of the Creek Indians, thoroughfares penetrated every section of East Alabama.

CHARACTER AND DISTRIBUTION OF ALABAMA ROAD BUILDING MATERIALS.

By William F. Prouty,
Chief Assistant Alabama Geological Survey.

We in the South, are just beginning to realize the possibilities and benefits to be derived from a good system of public roads. There are two great essential problems which confront us at the beginning. One problem is, what shall be our method of building and maintaining these roads? The other problem is what kind of materials shall we employ for the different kinds of road in the different parts of the State? We are concerned at this time with the latter question. This question is largely answered by nature in accordance with her distribution of the several materials. As a rule we cannot afford to haul for any great distance road building materials unless they are of exceptional value. We should consequently study the materials immediately at hand for the best results obtainable through them.

In the discussion of the road building materials we shall consider at this time only the natural materials and not the manufactured products. We shall moreover be able only to deal with this class of material in a general way. It is to be hoped that later the results of careful and detailed study of the various materials from characteristic localities throughout the State may be published; the location of possible road building material quarries mapped, and the detailed distribution and character of the better grades of road "metals" more definitely recorded. It is to be hoped that this study may be taken up by counties and the results placed on large-scale maps of approximately an inch to the mile. This detailed study, however, is for the future and cannot concern us at the present time.

The natural road building materials may be classed under three general heads according to their general mode of formation: First, the igneous rocks, or those which have cooled

from molten lavas. These may be light colored and with a large amount of the mineral quartz, therefore acid in their nature; or they may be dark colored with a high percentage of ferromagnesian minerals and basic in their character. The igneous rock may, further, be coarsely crystalline, (coarse grained) or finely crystalline (fine grained). Second, the sedimentary rocks, such as have been deposited mainly in water, and show planes of bedding or stratification. These may be either consolidated or unconsolidated. Third, the matamorphic rocks or such as have been subjected to great heat and pressure, and thereby have taken on a structure or texture different from the original one. The rock which is changed may have been originally either an igneous or a sedimentary rock.

Alabama is divided into three distinct physiographic regions (see map, frontispiece) and these three divisions are each marked by a distinct group of rocks. In fact the character of each region is a reflection of the character of rock which underlies it.

The Crystalline Area occupies some 5,000 square miles in the east-central part of the State, covering Lee, Coosa, Tallapoosa, Clay, Randolph, a large part of Elmore and Cleburne, and a portion of Chilton, Talladega and Calhoun counties. This area contains practically all the igneous and metamorphic rocks of the State, the most conspicuous being granites, syenites, "traps," gneisses, and schists.

The Paleozoic Area is marked by the district of the Appalachian valleys and ridges and the Cumberland Plateau. It lies in the north and northeastern part of the State, north and west of the Crystalline belt, and covers about one-fourth the area of the State. This area is characterized by the consolidated type of the sedimentary rocks such as limestones, sandstones, cherts, shales, etc.

The Coastal Plain Area in the southern and western portions occupies a little over one-half the area of the State and is characterized for the most part by unconsolidated sedimentary rocks such as soft limestones, clays and sands.

The chief tests which are applied to the solid rock types to determine their fitness for road material are: hardness, toughness, percentage of wear, and cementing value (see table of tests at end of chapter). The harder and tougher, the less the wear, and the higher the value of cementation, the greater is the value of the rock for roadbuilding. It must be borne in mind, however, that rocks which are very high in resistance to wear are only suited for heavy traffic, while those with rather low resistance to wear which have high cementing value, may be very excellent for use on country roads, where there is lighter traffic. It is therefore evident that one cannot say that this or that material is the best road building material in the State without at the same time designating for what kind of a road.

In the choice of our road building material too much care cannot be taken, for often it is just as expensive to use a poor grade as a good grade material. The resistance to wear, the hardness, the toughness and the cementing value will often need to be determined by a laboratory test, unless the person in charge is familiar with the qualities of the materials used.* The choice of materials extends, for example, even to the character of the clays used. A clay to give the best results in a sand-clay mixture should be high in plasticity and should have a low shrinkage on drying. In addition, the more readily a clay slacks, the more perfect a mixture it will make with the sand and consequently the better the result.

For a matter of convenience let us consider the road building materials of this State as they occur in the three physiographic regions already outlined.

THE CRYSTALLINE AREA.

This area, as has already been said, contains practically every kind of igneous and metamorphic rock. We will con-

*The materials to be tested may be sent either to the Office of Public roads Washington, D. C., freight or express prepaid, where they will be tested free; or they may be sent to the State testing laboratory, University, Ala., where they will be tested for a nominal sum, an amount sufficient to cover the actual expenses of such tests.

sider at this time, however, only those most important in road building, the "traps," granites, gneisses and schists. The gneisses and schists cover the greater part of the area. The gneisses toward the west are granitoid in their nature, but become more and more basic and dark colored as do also the schists, toward the east. The granites occur in large masses, more especially in the western part of the area where there are large outcropping masses known as "flat rocks." Long narrow outcropping dykes and sheets of basic rock, "traps," running in a general northeast-southwest direction, are very numerous throughout the greater part of the crystalline area. Especially is this true in the region of the gneisses and toward the central and eastern part of the area where the whole rock series seems to grow more basic in its nature. The narrow bodies of "trap" sometimes extend for miles in their N. E.-S. W. direction; and in some localities they are very numerous, being several to the mile. The Southern, the Atlantic, Birmingham & Atlantic, and the Central of Georgia railroads all cut through this productive area, and there are many places where the rocks could be worked in the railroad cuts for road surfacing. The "traps" of this area yield one of the most excellent materials for heavy traffic macadam, as they are low in wear and high in hardness, toughness and cementing value. The granites and gneisses and schists follow in about the order named in importance as road metals. All the above named rocks of the crystalline area are more suited for medium to heavy traffic than for light, and find their best use on town and suburban roads rather than on the country roads.

Up to the present time but little use has been made of the crystalline rocks for road building in Alabama, but there seems to be no reason why, with the growing demand for better roads, quarries should not be opened up along the railroads where high grade material could be placed on the cars at small cost.

In the crystalline area besides the solid rocks already mentioned, residual sands and clays, suitable for the construction of good country roads are to be found widely distributed.

Moreover in the southern part near the Coastal Plain area the Lafayette gravelly loam, which is so much used in other parts of the State for the construction of most excellent roads, is found in considerably extensive patches on the higher lands.

PALEOZOIC AREA.

In the division of the Paleozoic rocks we find a number of road building stones which are of excellent quality. The materials in this area which serve best for road making are, 1st, cherts of the Ft. Payne and Knox formations; 2nd, limestones which are of three varieties: the Cambro-Silurian (Knox), the Ordovician and the Sub-Carboniferous, which is represented by the Ft. Payne and Mountain limestone; 3rd, the sandy shales of the Carboniferous and Sub-Carboniferous; 4th, the residual sands, clay and gravels.

Of these materials the cherts have received, and justly so, the widest recognition. Of the two cherts, the Ft. Payne variety has been the most extensively used and gives, as a rule, better results than the Knox variety, though both are most excellent road metals. The Ft. Payne chert occurs in thick masses and beds in a fragmental condition ready for the steam shovel, while, as a rule, the Knox cherts do not occur in such extensive and pure masses and require more crushing. The cherts from this State show in the laboratory a medium resistance to wear, a good hardness, low toughness, and fair to good cementing value. The comparitively high cementing value of cherts over most forms of quartz is probably due to the fact that it is amorphous rather than crystalline, and is more readily dissolved by ground waters. Cherts are eminently suited for suburban roads of medium heavy traffic.

The limestones of the Appalachian valleys useful as road metals, are closely associated with the cherts and occur in unlimited quantities in places very easy of access. The Ordovician limestone, and the Sub-Carboniferous limestone, are being very much used for macadamizing purposes.

Wherever in the Paleozoic area of the State the cherts and the accompanying limestones occur, there we find a large pop-

A. Quarry in Mountain Limestone (sub-carboniferous) five miles west of Decatur. Morgan County.

B. Quarry in Mountain Limestone (sub-carboniferous) three miles east of Falkville, Morgan County.

Gravel pit in Fort Payne chert near Bessemer, Jefferson County.

ulation of thrifty people drawn to these localities by the rich limestone soils and the mineral deposits. Thus we have in these regions the greatest population in close proximity to high class road building materials.

In all the valley regions of the Paleozoic area we have what might reasonably be called inexhaustible supplies of chert and limestone, and furthermore since these valleys are the great natural passageways of the railroads and since there are hundreds of ideal locations for quarries along the railroads, the cost of delivering these macadamizing materials can be reduced to a minimum.

The great Tennessee Valley which stretches with its broad expanse east and west across the State north of the coal fields, is made almost entirely in limestone or cherty limestone, and the hills to the north are storehouses of chert. The Sequatchee, Wills, Murphrees, Cahaba and Birmingham valleys, are all narrow limestone valleys with either one or both sides paralleled by Ft. Payne chert ridges. The great Coosa valley which is made almost entirely in limestone, is interspersed in many places by ridges of chert of both the Ft. Payne and Knox formations. We see then that everywhere in the valley regions of the Paleozoic area the limestones and chert which are employed either together or separately in the construction of high class macadam roads, are very abundant and easy of access. (See Plate II, A and B, and Plate III.)

In the Plateau regions of the Paleozoic area, the district which is covered mainly by the coal fields, we find a much poorer grade of road building material. Here the ferruginous sandy shales are the best materials obtainable outside of the residual sands and clays which are very common and which, when properly mixed, afford an excellent and cheap country road. Along the northern border of the Plateau region, on the southern edge of the Tennessee valley, bituminous sandstones outcrop which may later be found of great value as a surfacing material in the construction of bituminous roads.

Coastal Plain Area.

This division covers more than one-half the area of the State, but its road building materials have received far less study than the two areas before mentioned. The possibilities of making good and cheap roads through nearly the whole of this region are most excellent, and as soon as a systematic study of the materials is made and the people properly aroused to the benefits of good roads, there is no reason to suppose that this portion of the State will not have as good highways as any other.

If with the existing geological data one could combine the results of a large number of tests of the materials from representative points in the different formations covering the area, information of great importance for the construction of roads could be readily compiled. From the existing geological data one can draw at this time the most helpful generalizations. There are a large number of formations crossing this portion of the State in belts running in a general east and west direction but swinging in a more northerly direction toward the western border. Briefly stated there are seven such belts which are of interest to us. Four of these belts are characterized by siliceous materials as sands, clays, or sandstones, and three belts characterized by calcareous or limy materials either of a soft or indurated nature. In detail these belts are as follows, beginning on the northern border of the Coastal Plain. (See map, Plate I, Frontispiece):

1. Alternating sands and clays, a belt some 40 miles wide in the northwest portion of the State and some 10 to 15 miles in Russell county on the east. Throughout the greater part of this belt excellent sand-clay roads could be made with short haul of materials.

2. A belt of "rotten limestone" (Selma Chalk) some 25 miles wide to the west and wedging out in Bullock county. This limestone belt passes through Epes, Demopolis, Selma, Montgomery, and north of Union Springs, and yields the typical "Black Belt" roads which are excellent in dry weather but almost impassable during the rainy season. This limestone

has a high cementing value and would make most excellent roads the year round if sand, gravel or crushed stone were applied to it in the right proportion.

3. A second sand and clay belt increasing from five miles in the west to thirty-five miles in width in the eastern part of the State. These sands and clays are more calcareous in their nature than those of belt 1, and sand-clay roads constructed from these materials should have a high binding character.

4. A second belt of limestone which has an outcrop in the west of about two miles in width and in the east of about ten miles. The limestone making this belt is commonly known as the Clayton or Midway, and varies considerably in thickness of bed and hardness in different parts of its outcrop. Specimens from Wilcox county and elsewhere taken from the more indurated portion show low percentage of wear, good hardness and cementing value, but rather low toughness. The above tests indicate that the limestone would locally make a good macadamizing substance for light traffic. Where not so indurated the limestone shows good cementing values and would be very useful with a siliceous matrix for road surfacing.

5. Overlying the Clayton limestone and outcropping in a belt some 35 miles wide immediately south of it, is a belt of siliceous material made up for the most part of sands and clays of the common type, interspersed by glauconitic (green sand) and shell marls and buhrstones. In this area a judicious mixture of the sands and the marls, or sand and clays should furnish excellent and cheap roads.

6. A third limestone belt, having an outcrop of about 15 miles in width running mainly through Choctaw, Washington, Clarke, Monroe, Conecuh, Escambia, Covington, Geneva and Houston counties. The limestone forming this belt is some 200 feet in thickness and is called the St. Stephens limestone from its typical exposure at Old St. Stephens Bluff on the Tombigbee River. This limestone in the west is rather soft but towards the east becomes indurated and silicified to such an extent that it is locally used for millstones, and would, in this portion of the State, serve as a good surfacing metal for

light traffic roads. The soft limestone of the west portion of the belt has a good cementing value and would be most excellent to mix with the siliceous materials of the belt either to the north or to the south.

7. Extending from the St. Stephens limestone belt to the Gulf are alternating sands and clays of more recent formation.

In enumerating the road building materials of the different areas and belts I have purposely withheld mentioning until now the most wide-spread and accessible, and at the same time one of the best of the road surfacing materials. This material is known scientifically as the Lafayette formation. It is composed usually of rounded quartzite or chert pebbles and a ferruginous clay. This gravel with its red clay mixture is very wide-spread in its distribution. Not only does it cover from 10 to 25 per cent. of the whole Coastal Plain but it is also found in the other two physiographic areas, especially in the portion bordering the Coastal Plain. These gravels are also found in many of the Appalachian valleys of the Paleozoic area, even toward the northern part of the State.

Lafayette gravel deposits vary in thickness from 0 to 50 feet or more and are found covering as a blanket practically every formation in the State. It is very probable that this formation at one time was more uniformly spread over the surface of the State and especially the southern portion than at present, but stream erosion has removed a large part of it.

The cementing value of this gravel is excellent and when used with the proper percentage of red clay which usually accompanies the gravel, it makes a splendid hard and smooth road for light to medium traffic. Many of the very best suburban roads of the State are made from the Lafayette gravel and clay.

For the larger part of the Coastal Plain area and for a ten or fifteen mile strip bordering the Coastal Plain in the Crystalline and Paleozoic areas, together with many places in the Appalachian valleys, a haul of more than 2 or 3 miles would seldom be necessary for the construction of roads made from

Pit in Lafayette gravel near Tuscaloosa, Tuscaloosa County.

Pit in Lafayette gravel, near Iuka, Miss. This gravel is much used in Alabama.

these gravels. Although it is often more economical to open a large deposit near railroad and ship short distance by rail rather than make any long hauls by team. (See Plates IV and V.)

Summary.

To summarize the above briefly, we can say that the State has three general districts which contain materials for the construction of roads differing widely in their character. In one, the Crystalline area, the hard, igneous and metamorphic rocks occur. Here the chief stones for road making are the "traps," the granites, the syenites, the gneisses and schists. Of these the "trap" rock is the most superior in quality but is somewhat limited in its distribution. The granites are confined more to the western portion of the area while the gneisses and schists are very widely distributed. In many places quarries could easily be opened in "traps" and granites along the railroads so that the highest class macadamizing materials which we have in the State for the construction of roads with heavy traffic, could be cheaply and readily shipped to such points in the State as material of this nature might be desired. Throughout the area, also, residual sands and clays and locally gravels occur adapted for the construction of the less expensive roads.

In another, the Paleozoic area, the road materials are still characterized by the consolidated type. They are, however, as a rule, more adapted to medium and light traffic rather than to heavy traffic roads, as is the case with the Crystalline area. Here the chief road building stones are the cherts and limestones and gravels in the valley regions, and sandy shales and residual sands and clays in the plateau regions. Through the richest portion of this area, where there is the greatest call for first class roads, the cherts and limestones are ever present in inexhaustible quantities and easy of access.

In the Coastal Plain area the road building materials are almost entirely of the unconsolidated type, but the distribution of the materials useful for making good roads suitable

for light traffic, is very general. The Lafayette gravels which occur in patches over the whole area are perhaps the most useful, and oftentimes the most economically applied, while the ever present sands and clays furnish most excellent materials for a good and cheap road.

In counties lying near the gulf, calcium carbonate in the form of shells of oysters and clams has been very successfully used in the construction of good roads.

There are a number of waste products in the smelting of ores and in the manufacture of different materials which have been successfully used in road building. Most of these products are so limited in quantity as to preclude their discussion at this time. Slag, which is the by-product from the blast furnace, although not of natural occurrence, is produced in such great quantities in our state as to warrant our attention here. This material is being used extensively as a foundation in the construction of macadam roads. On account of its porosity it has good binding qualities making it very suitable for this purpose with a surfacing either of "metal" or bitumen. Its brittleness precludes its use as a surfacing material. (See plate VI.)

While Alabama has not great "trap" talus cliffs like those of the palisades of the Hudson, or the Holyoke range of Massachusetts to draw from, yet all things considered, she is as well, if not more fortunately equipped, than any State in the Union for the construction of good roads throughout her entire area.

Slag quarry at Holt, Tuscaloosa County. Slag used as ballast and in construction of Macadam roads.

*TABLE COMPILED BY THE U. S. OFFICE OF PUBLIC ROADS FROM ROCK SAMPLES TESTED IN THEIR LABORATORY SHOWING MAXIMUM AND MINIMUM RESULTS CORRECTED TO JANUARY, 1908.

No. of samples.	Name.	Specific gravity.			Weight—lbs. per cubic foot			Water absorbed—pounds per cubic foot		Per cent of wear.		French coefficient. of wear.		Hardness.		Toughness.		Cementing value.	
		Max.	*Min.*	*Av.*	*Max*	*Min.*	*Av.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max*	*Min.*	*Max.*	*Min.*	*Max*	*Min.*
15	Amphibolite	3.10	2.70	3.00	193	168	187	1.65	0.04	10.3	1.0	41.7	3.9	19.0	13.5	29	7	235	11
23	Andesite	2.95	2.20	2.60	184	137	162	6.59	0.11	8.1	1.5	26.0	4.9	18.8	7.9	44	7	500+	19
62	Basalt	3.00	2.40	2.80	187	150	175	6.32	0.04	14.7	1.3	30.4	2.7	19.2	5.9	39	6	500+	4
36	Chert	2.95	2.00	2.60	184	125	162	11.10	0.43	27.9	2.7	14.6	1.4	19.7	12.7	26	5	106	4
4	Conglomerate	2.60	2.50	2.55	162	156	159	3.71	2.50	12.7	3.5	11.6	3.2	9.3	9.3	----	----	500+	----
142	Diabase	3.20	2.60	2.95	200	162	184	2.73	0.03	6.3	1.1	36.4	6.4	19.2	12.8	54	4	500+	2
36	Diorite	3.35	2.70	2.95	209	168	184	1.03	0.06	5.7	1.6	25.0	7.0	18.7	16.6	34	8	148	9
105	Dolomite	2.90	2.45	2.75	181	153	172	6.91	0.07	18.6	2.1	19.2	2.2	18.3	4.4	27	4	179	9
5	Eclogite	3.65	2.95	3.25	228	184	203	0.28	0.10	2.9	1.8	22.7	13.8	18.7	17.4	31	14	130	15
6	Epidosite	3.30	2.70	3.00	206	168	187	1.10	0.22	7.4	2.0	19.6	5.4	19.3	10.7	23	10	83	14
11	Felsite	2.80	2.50	2.65	175	156	165	3.13	0.02	3.4	1.9	21.3	11.8	----	----	----	----	----	----
89	Field stone	----	----	----	----	----	----	----	----	10.3	2.1	19.0	3.8	----	----	----	----	----	----
24	Gabbro	3.65	2.80	3.00	228	175	187	0.97	0.04	5.9	1.3	30.8	6.8	18.8	17.0	22	10	115	6
77	Gneiss	3.20	2.60	2.70	200	162	168	1.24	0.08	11.3	1.7	23.0	3.5	19.0	9.0	20	2	110	1
122	Granite	3.00	2.00	2.60	187	125	162	2.77	0.04	24.6	1.1	37.0	1.6	19.2	13.6	31	2	255	3
85	Gravel	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	500+	3
489	Limestone	3.15	2.00	2.70	196	125	168	13.22	0.03	34.2	1.8	21.7	1.2	19.1	0.0	25	2	500+	10
13	Marble	2.85	2.70	2.75	178	168	172	1.04	0.16	14.0	3.8	10.5	2.8	15.9	7.1	9	3	85	15
9	Marl	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	500+	96
19	Mixed stone	----	----	----	----	----	----	----	----	10.3	2.1	19.1	3.9	----	----	----	----	----	----
3	Peridotite	3.55	3.25	3.40	221	203	212	0.33	0.27	4.3	3.6	11.1	9.3	15.0	15.0	12	12	30	25
66	Quartzite	3.10	2.50	2.70	193	156	168	1.53	0.05	7.6	1.6	24.5	5.3	19.7	16.5	30	5	45	0
27	Rhyolite	2.90	2.05	2.35	181	128	147	6.11	0.03	9.7	1.7	23.0	4.1	19.7	15.3	42	6	500+	10
193	Sandstone	3.25	2.00	2.55	203	125	159	11.60	0.02	41.7	1.0	40.8	1.0	19.5	0.0	60	2	500+	3
87	Schist	3.20	2.65	2.95	200	165	184	1.35	0.06	12.8	1.8	22.6	3.1	18.9	0.9	35	3	232	7
9	Shale	2.70	2.50	2.65	168	156	165	4.84	0.50	16.2	3.2	12.6	2.5	17.7	13.9	12	3	367	28
33	Slag	3.90	2.00	2.80	243	125	175	4.40	0.04	13.5	2.7	14.6	3.0	18.0	10.7	21	3	463	1
42	Slate	3.35	2.60	2.75	209	162	172	2.10	0.05	6.9	1.6	24.4	5.8	19.7	1.1	40	1	500+	1
17	Syenite	3.05	2.15	2.70	190	134	168	4.21	0.10	14.4	1.7	23.5	2.8	19.2	17.3	34	8	375	16

*For explanation of results see following page.

EXPLANATORY TERMS USED IN TABLES OF ROCK TESTS.

Resistance to Wear.

Resistance to wear is a special property in rock, and although it depends to a large extent upon both the hardness and the toughness of the rock it is not an absolute function of these qualities.

The per cent. of wear in the table refers to the dust and detritus below one-sixteenth of an inch in size worn off in the abrasion test. The test is made in the following manner: Eleven pounds (5 kg.) of broken rock between 1 1-4 and 2 1-2 inches in size, 50 pieces if possible, are placed in a cast iron cylinder mounted diagonally on a shaft and slowly revolved 10,000 times.

The French coefficient of wear is obtained by dividing 40 by the per cent. of wear. Thus a rock showing 4 per cent. of wear has a French coefficient of wear of 10. The French engineers, who were first to undertake road-material tests, adopted this method of recording results. They found that their best wearing rocks gave a coefficient equal to about 20. The number 20 was therefore adopted as a standard of excellence. In interpreting the results of this test a coefficient of wear below 8 is called low; from 8 to 13, medium; from 14 to 20, high; and above 20 very high. Rocks of very high resistance to wear are only suited for heavy traffic.

Hardness.

By hardness is meant the resistance of a rock to the grinding action of an abrasive agent like sand, and is tested as follows:

A core 1 inch in diameter, cut from the solid rock, is faced off and subjected to the grinding action of sand fed upon a revolving steel disk against which the test piece is held with a standard pressure. When the disk has made 1,000 revolutions the loss in weight of the sample is determined. In order to report these results on a definite scale which will be convenient the method has been adopted of subtracting one-third of the resulting loss in weight in grams from 20. Thus a rock losing 6 grams has a hardness of 20—6/3 or 18. Experience has shown this to be the most convenient scale for reporting

results. The results of this test are interpreted as follows: Below 14, rocks are called soft; from 14 to 17, medium; above 17, hard.

Toughness.

By toughness is meant the resistance a rock offers to fracture under impact; such, for instance, as the striking blow given by a shod horse. This property is tested in a specially designed machine built on the pile driver principle, by which a standard weight is dropped upon a specially prepared test piece until it breaks. The height in centimeters of the blow which causes the rupture of the test piece is used to represent the toughness of the specimen. Results of this test are interpreted so that those rocks which run below 13 are called low; from 13 to 19, medium; and above 19, high.

Cementing Value.

By cementing value is meant the binding power of the road material. Some rock dusts possess the quality of packing to a smooth, impervious mass of considerable tenacity, while others entirely lack this quality. Cementing value should not be confused with the property possessed by Portland cement, which causes it to set into a hard, stone-like mass when mixed with water. The cementation test is made as follows:

The rock sample is ground in an iron ball mill with sufficient water to form a stiff, fine-grained paste. From this paste small briquettes 1 inch (25 mm.) in diameter and 1 inch high are molded under pressure. After thorough drying the briquettes are tested under the impact of a small hammer which strikes a series of standard blows. The number of blows required to destroy the briquette is taken as a measure of the cementing value of the dust. Some rock dusts, when thoroughly dried into compact masses, immediately slake or disintegrate when immersed in water. It is considered that the tendency to act in this way is not a desirable characteristic of a road material, as it would lead to muddy conditions on the road surface after rains. The test is interpreted so that cementing values below 10 are called low; from 10 to 25, fair; from 26 to 75, good, from 76 to 100, very good; and above 100, excellent.

Weight per Cubic Foot.

The weight per cubic foot refers to the weight of the material in the form of a solid and not as broken stone.

‡TABLE SHOWING TESTS OF TWENTY-SEVEN DIFFERENT SAMPLES OF ROCK

Kind of Material.	Geological age or Formation.	Locality.	Specific Gravity.	Weight per cubic foot.	Water absorbed per cubic foot.	Percentage of wear.
1. Limestone	Pelham	Dorville Switch, Jeff'n Co.	2.70	168	.10	4.6
2. Limestone	Pelham	Anniston, Calhoun Co.	2.7	168.4	.27	3.9
3. Limestone	Selma chalk	Faunsdale, Hale Co.	2.61	162	2.57	17.4
4. Limestone	Selma chalk	Uniontown, Perry Co.	----	----	----	----
5. Limestone	Selma chalk	Faunsdale, Hale Co.	----	----	----	19.1
6. Limestone	Selma chalk	Livingston, Sumter Co.	----	----	----	----
7. Limestone	Sub-Carb.	2 m. from Hartsell, Morgan Co.	2.65	165	.62	6.8
8. Limestone	Sub-Carb.	Cullman, Cullman Co.	2.7	168	.55	3.4
9. Limestone	Eocene	Snow Hill, Wilcox Co.	2.6	162	2.57	4.5
10. Limestone	Eocene	Furman, Wilcox Co.	2.6	162	2.76	4.8
11. Chert	Knox?	Leeds, Jefferson Co.	2.6	162.5	.7	----
12. Decomposed chert	Fort Payne	Anniston, Calhoun Co.	2.6	162	.7	----
13. Chert	Fort Payne	Francis, P. O., Calh'n Co.	2.45	153	1.74	9.
14. Chert	Fort Payne	Leeds, Jefferson Co.	2.6	162	.64	15.8
15. Chert	Fort Payne	Birmingham, Jeff'n Co.	2.45	153	3.40	9.5
16. Chert	Fort Payne	Birmingham, Jeff'n Co.	2.55	159	2.24	8.2
17. Sandstone	--------------	Hartselle, Morgan Co.	----	----	----	----
18. Sandstone	--------------	Cullman, Cullman Co.	2.45	153	.94	4.8
19. Limestone	--------------	Walthall's, Perry Co.	----	----	----	----
20. Gravel	Pleistocene	Athens, Limestone Co.	----	----	----	----
21. Gravel	Lafayette	Tuskegee, Macon Co.	----	----	----	----
22. Gravel	--------------	Tuskegee, Macon Co.	----	----	----	----
23. Cherty Gravel, white	Lafayette?	Tuskegee, Macon Co.	----	----	----	----
24. Cherty Gravel, yellow	Lafayette?	Tuskegee, Macon Co.	----	----	----	----
25. Limestone	Nanafalia	Pineapple, Wilcox Co.	2.5	156	4.89	5.3
26. Slag	--------------	Alicefureace, B'ham	2.7	168	.54	7.6
27. Slag	--------------	Birmingham	2.55	159	1.32	9.9

‡For explanation of tests see previous pages.

French coefficient of wear.	Hardness.	Toughness.	Cementing value.	REMARKS.
8.8	17.7	8	Good (57)	Rather hard with average resistance to wear, low toughness and good cementing value.
10.3	15.2	9	62	Fairly high in hardness and slightly below average for limestone in toughness; high in resistance to wear; good cementing value. Best suited for light traffic troads.
2.3	---	--	20	Best suited for very light traffic roads or to be used as a binding material with other rocks.
----	---	--	14	Below average in cementing value.
2.1	---	--	Excellent	Will make an excellent binding material with either rock or sand.
----	---	--	Excellent	Will make an excellent binding material with either rock or sand.
5.8	12.9	6	Good	Low in hardness, tougness and resistance to wear. A light traffic road material.
11.5	15.7	8	Good	A satisfactory road material under light traffic.
8.9	17.1	8	Good	Best suited for light traffic roads.
8.4	10.3	7	55	Soft limestone, average wear and good cementing value. Light traffic road.
----	---	--	Low	
----	---	--	Fair	Cementing value will increase under wear.
4.44	19.3	11	Fair	Cementing value will increase under wear.
2.5	---	--	Fair	Light traffic roads.
4.2	---	--	Good	Medium resistance to wear.
4.9	---	--	Good	Medium resistance to wear.
----	---	--	---------	Nature of material prevents tests.
83	15.1	10	Good	Medium hardness, low toughness.
----	---	--	87	Will develop fair cementing value if rolled wet.
----	---	--	Ex. (267)	
----	---	--	Ex. (400)	28% of this gravel was below 1-16".
----	---	--	75	Low cementing value caused by large amount of mica plates.
----	---	--	15	
----	---	--	19	
7.5	11.*	6	65	*New scale. Fairly hard, medium wear good cementing value.
5.7	---	--	Excellent	
4.	14.2	6	Fair	Medium hardness, low toughness and resistance to wear. Light traffic.

MACADAM ROADS IN ALABAMA.

By R. P. Boyd, Assistant State Highway Engineer.

The northern part of Alabama is rich in limestone and this material will necessarily be an important factor in the improvement of roads in that locality. The limestones in this section are of the upper and lower sub-carboniferous rocks of which there are two varieties: The lower limestone, gray, coarse-grained and crystalline; the upper, blue, fine-grained with but few crystals. The latter is the best road material and should be used when practicable. Quarries can generally be located along or near the roads and rarely will the stone have to be hauled over five miles. In locating a quarry, the cedar tree is an almost infallible sign of limestone.

Care should be taken in selecting the quarry site, for the quarrying is an important item in the cost. There are two distinct types of quarries: those where the stone lies in ledges or cliffs above the surrounding surface, in others the stone is found in flat ledges below the surface. I have found the latter, when free from water, were the best and cheapest to quarry, offering the best opportunity for mechanical elevation to the crusher. The cost of quarrying is approximately from forty to sixty cents per cubic yard, depending on the nature of the rock, the amount of stripping necessary, and the amount of mud-seams encountered.

Surveys, profiles and plans should be made in the regular way. Special attention should be given to the location of the road, and where old roads are followed, steep grades should be avoided. A five per cent. grade should be the maximum for it is practically impossible to maintain a water bound macadam road on a steeper grade. The maintenance in a few years will be greater than the cost of re-locating, even if the right-of-way must be purchased.

The limestone section offers excellent and comparatively cheap drainage, for generally ledges of rock can be located that make excellent dry masonry culverts up to spans of four

feet. These culverts are durable, cheap and not unsightly. An excellent concrete can be made from the crushed stone and screenings, which makes permanent and ornamental culverts, and when reinforced, can be used for bridges of small spans.

The grade should be finished and allowed to pack or settle for a period of two weeks before any macadam is laid. The sub-grade should be prepared at least one hundred feet in advance of the macadam. All soft places should be dug out and filled with firm dry earth and all holes filled. The sub-grade is then crowned with the road machine to the same crown that the finished road will have and then thoroughly rolled with a ten-ton roller. If any weak places are discovered while rolling, they should be taken out and replaced with suitable material and rolled again. The sub-grade, or foundation, is the most important part of any road and too much care cannot be given to this detail. A good road can never be made or maintained on a poor foundation. Macadam should never be put down in mud or soft earth, as it is absolutely essential that the sub-grade be dry and hard before the rock is spread.

The macadam should be laid in three courses, as follows: The first course of number one stone from 1 3-4 inches to 3 inches in size, spread from 4 to 5 inches thick and rolled with a ten-ton roller until the rock ceases to creep before the roller; the second course of number two stone, from 1-2 inch to 1 3-4 inches in size spread 3 to 4 inches thick and rolled as the first course. The first two courses can be dumped on the roadbed and spread to a better advantage with a small road machine with some assitance by raking. The third course, the binder, of No. 3 stone from dust to 1-2 inch in size, spread just thick enough to fill the void and form the bond. The best results are obtained by dumping the screenings on the side of the road and spreading by hand with shovel and rake. Sweeping with a stiff broom aids in working the binder into the interstices. After the screenings are worked in dry as much as possible, the surface should be flushed with water from a sprinkler and rolled as close behind the sprinkler as possible.

The sprinkling and rolling should be continued until the macadam is thoroughly bonded and ceases to creep before the roller. In many instances where water is scarce and the haul is long, it is cheaper to wet each wagon load of stone before it is dumped on the road. This can be done at some convenient well, stream or hydrant as the wagons pass by and it serves the purpose as well as sprinkling the material after being laid. The above courses give a thickness of about six and one-half to seven and one-half inches when completed.

The number two stone is the wearing surface and care should be taken not to get the screenings too thick and leave a crust over the number two stones. While it may appear smooth and hard at first, after a freeze or frost, a vehicle will pick it up in patches and cause holes and raveling. In rolling each course, the rolling should commence at the edges and work toward the center, preserving the crown of the road. The edges of the macadam should be kept straight and even by using six-inch boards to hold it in place. After the second course is laid, the boards should be removed and the berm rolled as the macadam is rolled.

The crown or slope to the ditches should be about five-eighths of an inch to one foot and on grades this should be increased enough to cause the water to drain to the ditches instead of down the roadbed. The berms or earth shoulders should never be less than three feet wide on each side of the macadam. These berms may be formed either by plowing out the center for the sub-grade and throwing up the berm with the road machine, or by taking the earth from the back of the ditches with drag scrapes. The latter method is best on fills as the height of the road will be increased. On new roads, especially on grades, the berms are liable to wash in gullies. This can be remedied by sodding with grass and in some cases, as in sandy sections, a thin layer of number one stone laid without rolling, will prevent washing.

The width of macadam roads is best determined by the amount of travel over the roads. Owing to the cost, few counties can build a macadam surface as wide as gravel or chert.

For the ordinary country road, a grade of twenty feet with macadam ten feet wide will answer every purpose. A road of this width will cost approximately three thousand dollars per mile. On heavily traveled roads and near towns the macadam should be wide enough to allow teams to pass without getting off the metaled surface. Macadam is the most costly road material in this State, but in some localities it is the only road material available, and it will, of necessity, have to be used. It makes an excellent road surface and when properly maintained is the most durable road material in this State. (See Plates VII and VIII.)

Splendid roads are made of oyster shells, the construction of which is similar to the construction of macadam roads. After the grade and sub-grade is prepared a course of natural shells is placed the required width to a depth of six inches and rolled, after which a second course of shells, which have been run through a crusher, is placed to a depth of two inches, dampened and rolled until the road is firm and hard.

GRAVEL AND CHERT ROADS.

By J. T. Bullen, C. E.
County Engineer, Montgomery County.

Gravel roads, or so-called gravel roads, vary greatly in the quality and quantity of gravel, and the methods of construction, in different communities.

In some counties, a gravel road means a chert road; in other counties, a gravel road may be only a good quality of sand-clay road, and there are many grades between these two extremes. To be specific, from a geologist's point of view, a gravel road would mean a road surfaced with fragments of rock, worn round under the influence of water or atmospheric conditions; but taken in a broader sense, any fragment of rock, mixed with sand, or unmixed, would properly be called gravel. It is well to bear in mind these different qualities when a question of cost is discussed.

Generally a county cannot afford to go out of its own boundary for road material. The problem then is generally how to best make use of local material; and since my subject is *gravel* roads, I shall confine my statements to roads built of that material.

In building a gravel road, the foundation, or sub-grade, is one of the essential parts. If the sub-grade is a porous soil, sandy or loamy, or a sandy clay, and naturally well drained, it will require less gravel to make a good road. The stiffer the clay, the greater the quantity of gravel necessary. Four or five inches on a porous soil will serve as well as eight or nine inches on a prairie mud.

As to Quality.

Chert, when of the best varieties, such as Fort Payne chert, is one of the very best road materials. If it is crushed or broken by hand so that no piece of it is over two inches in diameter, and the majority even less, it will make a very last-

A. Macadam Road, Morgan County looking east from city limits of Hartselle, Ala.

B. Macadam Road, Morgan County, showing cut at Outlaw Hill, five miles east of Hartselle, Ala.

Macadam Road, looking west, three miles east of Hartselle, Morgan County.

ing road. If any fragments of larger dimensions are used, even under the bottom, it will soon wear enough to expose the big lumps, and then you will have a road that is very rough, hard on horses, and especially hard on rubber tires.

Chert binds together better than any of the pebble gravels, or even limestone macadam, and the best chert road has little or no dust, and consequently little or no mud.

However, don't be misled, and believe that to specify chert is sufficient, for there are several kinds of chert found in one county, one very hard and durable, and another soft and chalky. See that you are getting the durable kind.

It is well sometimes to specify that the chert be spread in two layers, in order to prevent large lumps from being covered up.

I have seen a road built of clean chert collected from the foot of steep hills, where it had been washed against trees and fences, and the small quantity of black loam found with it made a fine binder.

I have used a chert that had few particles over one-half inch in diameter, and it made a very excellent road.

Chert is some times found in quarries of almost solid formation and when blasted separates into several sizes from very small particles up to the size of a water bucket. Chert of this sort is separated into uniform sizes by screens and applied on the road in layers similar to standard macadam construction and when so handled makes an almost perfect road.

After the chert gravel comes the water-worn crystalline variety, found sometimes in the bed of streams, mixed with sand or entirely clean, and again found in banks mixed with sand and clay.

The gravel with only sand for a binder will take a very long time to bind into a smooth, hard road, until some loam or clay or other binder is added.

A little ferruginous clay mixed with the gravel will, after it is thoroughly wet, set hard and firm. And even these bank or pit gravels vary greatly both in hardness and tough-

ness, and particularly in the proportions of sand and clay found with them. There seems to be streaks in all pits, sometimes a few feet wide, and sometimes many yards wide; sometimes the streaks have an excess of sand, and then again an excess of clay, rarely or never an excess of rock.

Sometimes the overburden of clay or sand and clay covering the gravel is only a few inches thick, then again it will run from three to ten feet thick. And again, it will generally be observed that the first two or three feet in depth of gravel contains more clay than the next layer lower down, and the pits frequently run into strictly sand gravel at a depth of four to eight feet.

Bank gravel is not to be judged offhand, for you may take a sample of gravel from one pit, and screen it carefully, or wash it, and find fifty per cent. of gravel remaining on the screen, and a sample from another pit, after screening or washing, may show only thirty-five per cent. of rock, and yet be a better gravel for road purposes. In the first sample, the balance of aggregate may be clay, in the second sample, containing actually fifteen per cent. less rock, the balance of aggregate may be a well balanced sand and clay, and under traffic in wet weather would hold up a heavier traffic than the first sample. And like concrete, a graded gravel with fine and medium and coarse rock will make a better, more uniform road than all coarse or all fine gravel. Except for grading as above mentioned, uniformity of the surfacing material is very necessary for the best results. If, in the hurry to load at the pit, one wagon is loaded with material from a clay streak and another from a sandy streak, and a third from a streak especially full of rock, it stands to reason that the road surface will have the same streaks. In dry weather, the clay streak will be smooth and hard, and the sandy streak will be loose; and in wet weather the reverse will be true. And after a considerable period of time, the extra gravelly streak will be hard and higher than the balance of the road, having worn less.

It is well to specify a gravel containing not less than sixty-five per cent. of rock to be retained on a No. 10 riddle, with

balance of aggregate about one-third clay and two-thirds sand. The majority of gravel now used in Montgomery county runs nearly 75 per cent. rock and about the above proportions of sand and clay.

The gravel itself is brittle, and breaks easily under traffic, forming a binder of itself.

I find, as a general thing, that the pebble found in sand banks is a harder, more durable gravel than that found mixed with clay. And the hard gravel, when screened and mixed with a good clay, makes a very lasting road; after screening, enough sand remains to keep the clay from being too sticky.

It is much easier to build a road of sand and clay gravel than of limestone, or any other macadam surface. The gravel is easier to spread and shape, binds more readily, and frequently has enough moisture in it to save the expense of sprinkling.

A roller of, say ten tons, or even five tons, will be of servic in building gravel roads, but where there is heavy traffic, or much light traffic, a roller is not necessary, as in macadam road construction. However, it is very necessary to keep the gravel surface to a crown, either by rakes, or better, by road machines, until it has packed hard and smooth. The traffic will do the rolling, but the road machine dressing it daily for, say, ten days after traffic is turned on it, will fill the ruts and keep the crown in shape, and after a few rains or dailv sprinkling a hard, smooth road will result. Care should be exercised in spreading gravel uniformly over road surface, but it is by no means so important as in macadam roads, for if the road machine is frequently used, a very even distribution of gravel will result.

I sometimes specify that the sub-grade for gravel shall be cut out, leaving a solid shoulder on each side, cutting half the depth of gravel, and using the earth cut out to build up the other half of shoulder, requiring the sub-grade to have the same crown as the finished road, generally three-fourths of an inch to one foot, the gravel to be spread same depth at center and at sides. Then again, I specify grade to be built flat, with the crown formed by the gravel, spreading gravel, say,

nine inches deep at center, and six or seven inches at sides, and shoulders to be then given a crown with road machine, and gravel feathered out at edges with road machine. On a wide grade, with light travel, the latter way is perhaps the better; on a narrow grade the former is better.

And when the former method is used, and the sub-grade is not of a porous material, it is well to have lateral trenches across the shoulders, dug to the depth of gravel, and six inches wide, and filled with clean gravel, to allow the water percolating through gravel surface to escape from the sub-grade to side ditches. These blind drains are especially serviceable at the foot of grades.

I usually specify that all gravel shall be back-dumped; that is, hauled to far end of work first, using sub-grade to travel over. This travel on sub-grade packs it as few rollers could do,—develops the soft spongy places, and saves the wear of the gravel.

It is not always wise to adhere to this rule, for in some cases the reverse is the better way. If sub-grade is sandy and difficult to haul over, the travel will not pack it, and the rule would only make a contractor bid higher than if allowed to build road and advance over it as fast as completed.

Then, two, if gravel is put down, and hauled over at once by a contractor with heavy loads of gravel, it will more surely be dressed with road machines, and be in a compact finished condition by the time the far end is spread.

Again, on a clay sub-grade, after rains, heavy loads are impossible, and contractors bid to cover delays.

So in this rule, as in most others, common sense must decide which it is better to specify.

I also specify the use of seven-inch or nine-inch planks, as the case may be, to confine the gravel in sub-grade trench, or on flat sub-grade, to insure a uniform depth of gravel, as well as a true alignment, only a few hundred feet of boards being necessary, as they are taken up and carried forward as fast as the berms, or shoulders, are completed.

Pegs at intervals of ten feet down the center are sufficient to insure proper depth.

I believe it a much better plan to specify so many inches of loose gravel than so many inches of compacted gravel. You can see the quantity of loose gravel spread by the boards and pegs, and you can require it rolled until you are satisfied; if it compacts to eight inches, or six inches, there is no dispute with the contractor as to depth of finished work.

You may specify nine inches in depth loose, twelve feet wide, which would require 1,760 cubic yards of gravel. Allow one or two per cent in excess of that amount, to make it practical. Have inspector require the loose gravel to come flush with top of boards; agree to pay the contractor not over two per cent. in excess of the theoretical amount required, and he will be sure to have his sub-grade free of holes.

There are few gravels that contain any appreciable per cent. of clay that will compact alike; sometimes they will compact fifteen per cent. under rolling, and in others will compact as much as thirty per cent. If you plug the finished road, in an endeavor to see if the full nine inches has been applied, you will find the finished depth varies not only with the amount of rolling, but with the proportions of sand and clay and pebbles in the aggregate.

Montgomery county owns a large gravel pit, and pays a contractor 12 1-2 cents per cubic yard to load the gravel on cars, which is done with a steam shovel. The shovel has a capacity sufficient to load about forty cars a day, averaging twenty-five cubic yards to the car. From the pit the gravel is distributed through the county to the railroad stations nearest the work, and hauled from the station to the road by teams.

In one contract, we have allowed the contractor to build a narrow-gauge railroad down the grade for some miles, and the price bid by the contractor to whom the work was awarded was $10.000.00 cheaper than any of the bids made by contractors who figured on doing the work altogether by teams. The contractor uses three-yard cars and a Shay geared locomotive, and is able to pull a heavy load up grades as steep as 5 per cent. I believe this method is a good one for large contractors on long hauls.

As to Cost.

The cost of a road, gravel or macadam, can be likened to the cost of a house. It depends on what kind of a road will meet your requirements. Houses vary from cheap, two-room houses, costing, say, two hundred dollars, to the mansion costing two hundred thousand. And roads will vary in the same way. Some very fair roads cost only a few hundred dollars, and others cost as high as two hundred thousand dollars, or more, per mile.

The amount of grading, the bridging, the width and depth of gravel, and the length of haul, are all important factors in the cost of roads.

A road built over a gently undulating country may have easy grades, with only light grading, and the culverts and bridges may be few in number, and the gravel may be found adjacent to the road, requiring only a short haul.

Again, the grading may be five to ten feet high to get above high water, and bridges frequent and expensive; the gravel may be five or six, of even ten or a hundred miles from the work, and a railroad haul, as well as a long wagon haul, necessary to deliver it.

A good team will make from twenty to thirty miles a day. On short hauls, as many as twelve or fifteen loads of gravel may be delivered on the road by one team; and if teams could be procured for $3.50 per day, the gravel would cost 23 1-3 cents per load for hauling. A road 16 ft. wide and 9 in. deep would require 2,347 cu. yd., which, at 23 1-3 cents, would be $546.85 for hauling. If the gravel was five miles from the work, the same team would probably make three trips per day, making cost of hauling per cubic yard, at same rates, 70 cents per cubic yard, or $1,642.90 for hauling sufficient gravel for one mile of road; in other words, for the same identical result as to road surface, the road built with long haul would cost, in round numbers, $1,100.00 per mile more than the road with short haul. I make this comparison to show how rapidly (under varying conditions) the cost for the same grade of road may vary.

Under average conditions, a road graded 20 feet wide, with gravel 12 feet wide and 8 inches deep, can be well built for

$2,400.00 per mile. Under most favorable conditions, the cost may be as low as $750.00 per mile; hardly less, if it is well built.

MAINTENANCE.

It is easy enough to keep a few miles of gravel road in repair, but when the mileage gets up to the hundreds, it becomes a problem.

The patrol, or continuous repair system, is good, if you can carry it out.

We have tried negroes with mules and carts, but each negro required a good foreman behind him, to get any results. Where reliable white men could be employed for nominal sum to patrol a section of road and keep it up, the patrol system would give good results.

In Montgomery county, we are working under the general State law, and have divided the county into nine road districts, and hired an overseer for each district, at $50.00 per month, to take charge of the roads in his district. Each overseer is given two good wagons and teams, two tents, a road machine, shovel, plows, bush-hooks, etc. Before beginning work, each overseer is required to ride over his district and get the name and address of each person in his district liable for road duty, and a copy of said list was furnished the county engineer. He keeps a regular account with each road hand, charging him with ten days work, or $5.00 a year, and crediting his account from week to week as the overseer reports that he has worked or paid.

Since all overseers are paid a salary, and their job depends on their making the road hands work or pay, it is a much easier matter to get the work done.

This is the first year Montgomery county has tried this system, and it is not perfected, but it is a wonderful improvement over the old methods.

The most intelligent overseers are accomplishing great results, and I believe they will improve rapidly with experience. The outfits under overseers can do little new work, but are supposed to maintain the present roads in the districts.

When a gravel road becomes worn irregularly,—a hole here and there, we use a scarifier of several tons weight, with four spike teeth at each end, to drag over gravel and loosen the surface to a depth of several inches. Then by reshaping the surface with the road machine daily until travel packs it smooth, we have a cheaply repaired road.

If the road surface has deep holes, it is better to refill them with fresh gravel, before scarifying the surface. It is a difficult thing to make a smooth, satisfactory patch, but with the scarifier it is simple.

The scarifier is intended to be dragged by a traction engine, or steam roller, but we frequently hitch twelve mules to it and plow up the road for much less than it could be done with six or eight mules and a rooter plow.

As to Length of Life.

One of the chert roads in Montgomery county held up well under fourteen years of travel, though large lumps were allowed on the road, and they projected from two to six inches above the general surface, making a hard road, but a very bad one on horses and tires.

The screened gravel roads (hard, flinty, water-worn pebbles), under heavy travel, held up pretty well for seven or eight years; after eight years they were badly worn and rutted.

The clay gravels unscreened lasted five or six years.

Repairs on a gravel road, like on any other road, should begin almost as soon as completed; and especially so if there are any grades deeper than 3 per cent. It is a mighty good investment to reduce grades to 3 per cent. or less, to save repair bills; for one torrential rain will begin the destruction of the surface on steep grades.

The length of life on any gravel road will depend on how carefully it is built, with what character of gravel it is surfaced, the amount and character of travel, and the system of maintenance.

(See Plates IX, X, XI, XII, XIII, XIV, XV.)

Gravel road, Montgomery County. Court street road two and a half miles from center of city. Road built over black prairie soil with Lafayette gravel; sixteen feet wide, spread nine inches deep loose, and rolled with ten-ton roller. Road about two years old.

Gravel road, Montgomery County, near City of Montgomery. This road is ten years old. It has been scarified, several inches of Lafayette gravel added, and resurfaced with road machine.

Union Academy and Ada gravel road, Montgomery County. Old road has 9 per cent. grade, new location 50 feet north, has a 4½ per cent. grade. Built of Lafayette gravel.

Tuscaloosa-Birmingham road, two miles from Tuscaloosa. The banks along the road here are made of Lafayette gravel and loam, the materials from which the road is constructed.

Jackson chert road. Just out of Florence, Lauderdale County, made of "creek gravel" (Fort Payne chert.)

Chert Road between Birmingham and Ensley, built of Fort Payne chert.

Street in Birmingham built of Fort Payne chert.

PRACTICAL SUGGESTIONS ON SAND-CLAY ROAD CONSTRUCTION.

By W. S. Keller, State Highway Engineer.

In the preparation of this article on a subject which has been so ably treated in bulletins by the U. S. Office of Public Roads, the author is conscious of his limitations and does not attempt to write a text-book, or theoretical article, but simply a statement of what sand-clay roads are, and how they can be built.

Every farmer who lives in a section of country where both sand and clay are prevalent, is more than likely traveling over a section of natural sand-clay road and still, more likely, is ignorant of the fact. He can no doubt call to mind some particular spot on the road he travels, though it may not be more than 100 feet in length, that is always good and rarely requires the attention of the road hands. Good drainage will be noticed at this place and if he takes the trouble to investigate, he, no doubt, will find that a good mixture of sand and clay forms the wearing surface. If this 100 feet of road is always good, then why can't the entire road be made like it? It can, provided man will take advantage of the lesson taught by nature, and grade the road so that drainage will be good, and surface the balance of the road with the same material. If it is not possible to find this ready mixed surfacing material convenient to the road to be surfaced; it may be possible to find the two ingredients in close proximity. In case the road has a predominatingly sandy character clay should be added or in case clay predominates, sand should be added to produce good results.

There are four general ways in which sand-clay roads may be built:

1. Ready mixed sand and clay placed on clay, sand or ordinary foundation.
2. Sand and clay placed on soil foundation and mixed.
3. Clay hauled on a sand foundation and mixed with the sand.

not very effective in this work, however, it would appear that a tamping roller, such as has been used in the construction of the oil roads of California, would be very effective. A split log drag is an indispensible machine in the construction of any kind of sand-clay road.

Second: Sand and clay placed on a soil foundation and mixed. This is necessary where the old road has neither a clay or sand foundation and it is impossible to find the two ingredients ready mixed, but possible to geth both in separate state near at hand. The clay should first be placed on the road to a depth of 4 inches and the required width. It is not wise to place more than a few hundred lineal feet of clay before the sand is hauled, as the clay rapidly hardens and makes the mixing process difficult. After, we will say, 400 feet of clay has been placed, the clay should be broken by means of a plow and harrow, if it has become hard, and sand to a depth of 6 inches placed on it. This should be plowed and harrowed in thoroughly. This is best done immediately following a rain as the two can be more satisfactorily mixed. Traffic aids the mixing and should be encouraged on the road. After the mass appears to be well mixed the road should be properly shaped as previously explained. The road should be given watchful attention and, should sand or mud holes appear, a second plowing and mixing should be given it.

Third: Clay hauled on a sand foundation and mixed with the sand. The mixing process is similar to that described under second head. It is only necessary to add that, as the foundation is sand, a little more clay will be necessary than where the foundation is of clay or soil.

Fourth: Sand hauled on a clay foundation and mixed with clay. The clay foundation should be plowed to a depth of 4 inches and harrowed with a disk or tooth harrow until lumps are thoroughly broken or pulverized. Sand should then be added to a depth of 6 inches and mixed as before described.

Sand and clay can be mixed best when wet, but as most road construction is done in the summer months, it rarely rains just when you are ready, so we are compelled to do most of the

Pike County sand-clay road. Scene four miles from Troy, on Troy and Elba road. View looking towards Troy.

Pike County sand-clay road. Scene about three and one-half miles from Troy, on Troy and Elba road. View looking towards Troy.

Pike County sand-clay road. Scene five miles from Troy, on Troy and Ozark road. View looking towards Troy.

mixing dry and keep the road in shape after the first two or three rains, while the passing wagons and vehicles give the road a final wet mixing. The cost of sand-clay roads, like any other kind, varies greatly, depending on the character of grading and the proximity to the road under construction of the surfacing material. Good sand-clay roads can be built from $500 to $1,500 per mile. In some places where underneath a five or six inch surface of sand, a good sand-clay is to be found and this is on a level stretch of road,, by means of a large grading plow and machine, turning the sand under and shaping the road up, a mile can be built for $250 or $300.

A sand-clay road is the cheapest road to maintain for the reason that it can be repaired with its own material. By this I mean that with a split log drag or grading machine ruts can be filled with material scraped from the edges, whereas on gravel or macadam roads, such is not possible. The repairing of these roads can be done almost exclusively with the split-log drag, only enough hand work being required to keep the gutters open and growth of weeds cut on the shoulders.

Those contemplating the construction of sand-clay roads or any other kind of roads should bear in mind that in road construction, more so perhaps than in any other kind of work, does the old adage of "What is worth doing is worth doing well," apply.

(See Plates XVI, XVII, XVIII.)

EARTH ROADS.

By Wm. F. Prouty.

More than 96 per cent. of the roads of Alabama are unimproved and belong to the type known commonly as earth roads. Over this class of road still moves a great percentage of all our traffic, and doubtless this will be the condition for many years to come. It is consequently logical that the welfare of the earth road should receive the first and the most important consideration. As it stands today, however, the earth road is perhaps the mot abused and neglected of all our public highways.

The orinary country road is, as a rule, either a sand or a clay road, or a mixture of the two in some proportion. The methods of construction and maintenance of a sandy road are radically different from that of one made of clay. This is so because the action of water on the two is radically different. Moisture improves the sandy road but greatly injures the one made of clay.

The sand-clay road which blends the good qualities of both clay and sand, is not infrequently found in nature, and its artificial construction is most earnestly recommended for country districts. (The subject of sand-clay roads is treated elsewhere in the bulletin.)

The most important thing in the construction of any road is its location. It is the only permanent thing about it. Upon location depends the grade, which in turn regulates the rate of erosion and the amount of load which it is possible for a team to haul. (Plate XIX.)

*The second most important thing in connection with the construction of a road is its drainage. Because of the different actions of moisture on sand and on clay we find that different rules apply both to the location and the drainage of roads made from these different materials. A sandy road should be

*See Chapters on location of roads and on drainage of roads.

New graded earth road through carboniferous shales and sandstones, one mile west of Cordova, Walker County. This road replaces one which is twice as steep and practically as long.

kept as moist as possible, since in that condition it is much firmer and offers much less resistence to traction. The moisture may be maintained in the sandy road for a considerable part of the year by having the road bed lower than the sides of the road so that the ground-water may stand higher relative to the road, than is usually the case in the ordinary shaped road.

The less the sunlight on a sandy road the better. Thus it is usually best that a sandy road be located on the northern rather than on the southern slopes, if there is a choice, and in wooded areas rather than in open ground.

A clay road should be kept dry to be in the best condition, and consequently the road should be so located as to receive the maximum amount of sunlight, as would be the case on the southern slopes of hills, and away from the shades of trees and the moisture gathering influence of humus. The ground-water level should be kept well below the road bed, and the road should have a crown sufficient to quickly shed the water which falls on it. Smoothness of the road surface is here also very essential since holes or ruts catch and retain the rain water thereby softening the road.

In order to keep a road in good condition where there is an increased percentage of clay, the crown must be steeper, the surface smoother, the ground-water level lower, and the amount of sunlight received greater.

Of the two extreme types of the earth road, the sand and clay, the sand road can be much more neglected and still be passable, but it can never be a good road. While the clay road requires much more care to keep it in a passable condition, it is at the same time capable of being made into a much better road.

Concerning the construction of earth roads Mr. W. S. Keller, the State Highway Engineer, says as follows:* "Very few earth roads have in the true sense been constructed. The average road is opened without regard to grade or proper loca-

*From paper read before the National Good Roads Association, Birmingham, May, 1911.

tion and simply because it is desirous to have it pass A, B and C's houses. The opening consists in cutting down any trees or brush that can't be avoided by crooks and bends, leaving the stumps just high enough to allow wagons to pass over and requiring expert driving to miss. This highway is then ready for traffic. Unfortunately homes have been built and improvements made near and abutting these old roads to such an extent, that it is detrimental to such property to make any great change in location, or rectify bad allignment and grades. Of course beneficial changes can be made in many places that will be an advantage, not alone to the road but to the abutting propertly.

"In the reconstruction of an old earth highway the proper officer should first go over the road noting the changes th-+ should be made. He should bear in mind especially: initial cost, cost of maintenance, the allignment and the grade. The centre line of the road should be established by an engineer if it is possible to secure one. If an engineer cannot be secured, the ordinary method of lining a fence can be used; that is, by means of sight poles. After the centre line has been established and width of road agreed on, you are ready for construction work. The proper and efficient grading force for this work should consist of a foreman, eight or ten good two-horse teams and drivers, one wheel and one drag scrape for each team, and one extra wheeler and drag for emergencies, one good railroad grading plow, one grading machine, one split-log drag, one dump man and one loader with five or six extra men for grubbing and other work. The foreman should be an experienced grading man who understands handling earth and knows when it is proper to use drag scraps, wheel scrapes or wagons. The road should be so graded that the ditches or gutters are parallel with the centre line of the road and of equal distance from it. When completed the road should be uniform in width and the surface should be smooth and even, free from holes and high places and with a uniform crown having a fall of one inch to one foot, from centre to gutter. On grades this rate of fall should exceed that of the grade to

such an extent that water will readily flow to ditches instead of down the road. Drain pipes should be freely used and no water should be allowed to flow over the road if it can be avoided. In some cases it is not practicable to build the road above high water. In such cases, danger signs should be posted, showing at what stage the water becomes too high to allow fording of the stream.

"We have in the South nearly every kind of soil, from sticky gumbo on the one hand to coarse sand on the other. The method used for improvement of road through a section of one will not do altogether for the other. The worst roads that we have in the South are in our rich and fertile prarie lands, where unfortunately, there is very little road building material to be found. This soil readily absorbs water and becomes very sticky after rain. It expands freely and dries rapidly when the sun shines, and becomes very hard under the tamping effect of team and vehicle. From observation and experience I have learned that these roads of all others, require a very high crown and the driving surface should be only wide enough to allow two vehicles to pass. If a prairie road is narrow with a fall of not les than one and one-half inches to the foot, water will shed rapidly to the ditches and the entire surface will dry out quickly. A road of this kind can be constructed quickly and at little expense, except where grades are to be reduced or bottoms filled. No earth road can be maintained in good condition unless it is so constructed as to drain well and unless it is kept free from ruts and holes."

The chief problem of interest to us in connection with the earth road after construction is maintenance, since it is upon maintenance that practically all the money is spent or thrown away for earth roads. Especially is this so in regard to the earth roads of a more clayey character. It is relative to this latter type of dirt road that I wish especially to call your attention. Here the elimination of water is the all important problem. This is done in two ways either by underground or by surface drainage. In the first case drainage is usually accomplished by longitudinal tile or rock drainage, and in the

second case by a sufficient crown of road and lateral ditches.†

Any discussion concerning the maintenance of earth roads would be very incomplete without setting forth the utility of the split-log drag. The split-log drag or drag of similar efficiency, is neither a fad nor a political machine, although the politicians are strongly advocating it. It is the most useful and economical instrument yet invented for maintaining the earth road. *Statistics show that an extremely small number of the citizens of our State are taking advantage of this opportunity. If the road drag were systematically used throughout our country districts we would not only directly save many thousands of dollars annually by the reduction of the necessary road tax but we would also have dirt roads which would be far superior to the present ones. There is no question of the truthfulness of this statement.

The states using the split-log drag extensively have found that the cost per year per mile to keep the road in good condition through the use of this instrument after the roads have once been shaped up, is approximately $6.00. In the State of Alabama there is at the present spent per mile per year for road improvement and maintenance about $32.00. The saving of a split-log drag would obviously be very great since a large percentage of the earth roads of the State are of a clayey nature and are the ones which at present are the most costly to maintain.

If the road to be dragged is badly rutted or out of shape, or if it is too narrow with no ditches, the road should first be graded before the drag is used. As a rule, however, the roads will not require much of this preliminary shaping up since the drag itself opens the ditches and draws the earth toward the center of the road, thus crowning as well as smoothing it.

The crown of the loamy soil road should be approximately one inch per foot and of the clay road one and one-half inches per foot.

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†See chapter on drainage of earth roads.

*Statistics recently gathered from R. F. D. men of the State and also from county officials by the Alabama Geological Survey.

The purpose for using a drag on a road is to smooth the surface and maintain the crown. The clay from the traveled portion of a road becomes so fine through wear that it is practically impervious to water. If there are holes left in the road they hold the rain water for long periods, and the road becomes consequently softened and the ruts deepened. If, however, these holes are filled with clay and the surface of the road uniformly smeared with the impervious material, there is little chance for the rain water to penetrate or damage the road. The clay thus spread over the surface when it is wet (the dragging must be done when it rains or immediately after a rain while the road is soft), is baked by the sun into a hard coat that makes an excellent wearing surface. Traffic tends to compact this coat and to tamp the material into the former holes. With each dragging the road becomes harder and smoother and the effect of rain on it grows less and less.

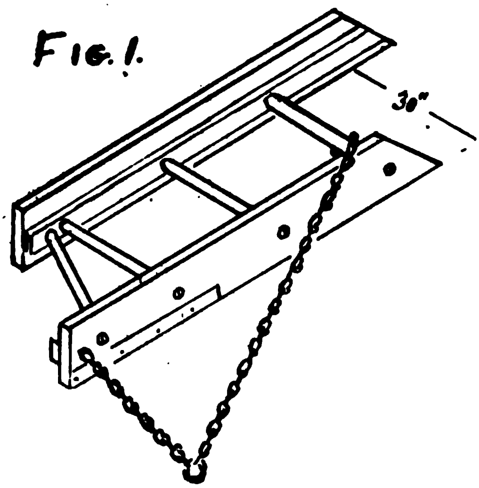
There are many kinds of home-made wooden drags which have been used with success. Figures 1 and 2 taken from Wisconsin Geological Survey publication, show the most common types with the general dimensions of each. Of the different types the split-log or the plank drag, made on the same general pattern, is perhaps the most useful and economical. The cost of the material for the drag should not be more than three or four dollars. In their construction a light weight wood rather than oak or hickory should be used, as it is much more easily handled and equally as efficient. There are also a large number of excellent drags of different styles which can be purchased at relatively small cost.

Roads properly dragged will dry out much earlier in the spring than they otherwise would, and since they are less rutted during the winter will also be much smoother and harder when dried out.

Dragging should be more frequent during winter and spring than in summer, but twice a month on an average is usually sufficient to keep the road in good condition.

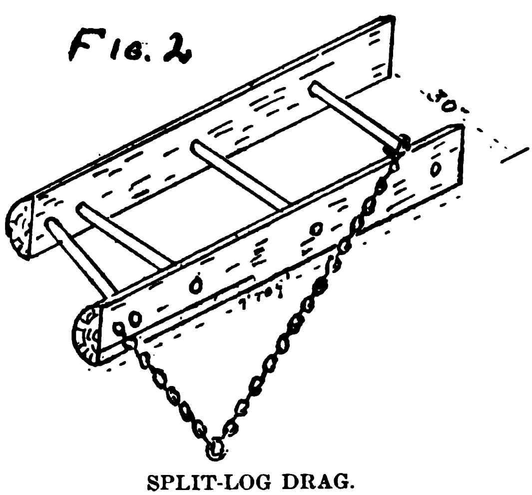
The following practical instructions for dragging are taken from the first report of the Illinois Highway Commission:

Fig. 1.



PLANK DRAG.

Fig. 2.



SPLIT-LOG DRAG.

"Make a light drag, which is hauled over the road at an angle so that a small amount of earth is pushed to the center of the road.

Drive the team at a walk.

Ride on the drag; do not walk.

Begin at one side of the road, returning on the opposite side.

Drag the road as soon after every rain as possible, but not when the mud is in such a condition as to stick to the drag.

Do not drag a dry road.

Drag whenever possible at all seasons of the year . If a road is dragged immediately before a cold spell it will freeze in a smooth condition.

The width of traveled way to be maintained by the drag should be from 18 to 20 feet; first drag a little more than the width of a single wheel track, then gradually increase until the desired width is obtained.

Always drag a little earth towards the center of the road until it is raised from 10 to 12 inches above the edge of the traveled way.

If the drag cuts in too much shorten the hitch.

The amount of earth that the drag will carry along can be very considerably controlled by the driver, according as he stands near the cutting end or away from it.

When the roads are first dragged after a very muddy spell the wagons should drive if possible to one side until the roadway has a chance to freeze or partially dry out.

The best results from dragging are obtained only by repeated applications.

Remember that constant attention is necessary to maintain an earth road in its best condition."

The following suggestions for using the drag are taken from the monthly bulletin of the Missouri Board of Agriculture for April, 1906:

1st. "The length of the chain, which is regulated by slipping it backward or forward through the hole in ditch end of drag. The length of the chain regulates the hold taken on the earth. To make the chain longer is equivalent to putting weight on the darg. If your drag is too heavy shorten the chain."

2nd. "The position of the snatch hook, which attaches the doubletrees. To move much dirt or cut small weeds hitch the hook close to the ditch end of the drag and stand as nearly on the end of the front slab as is safe. Drive very slowly when thus hitched. This one hitch seems to be the hardest to learn. The others suggest themselves.

3rd. "Position of the driver on the drag. To move dirt see above. In a soft spot stand on rear slab. On a hard spot stand on front slab and drive slowly. If the drag clogs with straw, weeds, sod or mud, step to a point as far as you can get from ditch end of the drag. To drop dirt in a low place step quickly from ditch end to other extreme. To fill a low place or mud hole nicely is the severest test of skill with a drag.

"I suspect you will become thoroughly disgusted when you first make the effort. But remember it will not be the fault of the drag if you fail.

4th. "Presence or absence and sharpness or dullness of the steel. The steel may project half an inch below the wood at the ditch end of the steel, but should come up flush with the wood at other end of the steel. After a clay or gumbo road has been dragged four or five years the soil becomes so tough and putty-like that one must study it closely to know what to do. Sometimes I use sharp endge of steel; sometimes dull edge (holes are bored in both edges of steel so that I can turn it up side down and use same bolt holes), and sometimes the plain wood.

"This can be learned only by experience and you have several years in which to study the problem.

"I hope these details and fancy points will discourage no one. Never forget that the poorest drag used in the poorest manner by a man who wants to learn will surely improve the highway."

There are numerous ways in which the work of dragging the road can be carried on. In some places the farmers living along the road, drag them in accordance with the instructions of the superintendent of roads. They are allowed a certain amount of time in which to do the work at a stipulated price per hour. In some places the farmers have organized to carry on the work for their own benefit without expense to the town. In some western cities the merchants have offered prizes for the best maintained road in their community by the use of the drag, thus encouraging the farmers to compete in the bettering of roads. (Good roads help the farmer and the merchant). Another plan, and one which seems to be more feasible than the others, is to contract with road superintendent to keep the roads in a given district in good condition by the use of the drag for so much per year.

The best recommendation the road drag can have is the fact that wherever it has been properly used on clay roads its use has been enthusiastically continued.

DUSTLESS ROADS AND BITUMINOUS BINDERS.

By Wm. F. Prouty.

The present tendencies in road construction are far different from what they were 10 years ago, and there has probably been no time in the history of road building, in the South, when the tendencies have been changing more rapidly than they are at the present time. The factors instrumental in causing this change of tendency in road construction and maintenance are many. Chief among them, however, should be mentioned the following: 1. Bond issues and money taxation make it possible to construct roads of greater initial cost and better class, and also to construct them more cheaply than it would have been possible with the older form of labor taxation. 2. The people are beginning to realize the great financial, social, and educational losses occasioned through bad roads. 3. The rapid development of automobile transportation has made absolutely essential hard smooth roads for their efficient use. The automobile men are more often the men of influence. 4. The rapid wear and the great amount of dust on certain classes of these hard, smooth roads is preventible by certain methods of treatment. 5. The public is awakening to the great nuisance and damage caused by dusty roads.

The most advanced step in the treatment or construction of roads is that which, besides making the road the most serviceable for the condition of traffic to which it is to be subjected, makes it also a relatively dustless road. It is this tendency to the construction of dustless roads to which I wish to call your attention.

There are a number of questions which naturally suggest themselves at this point such as: Where should dustless roads be built; how should dustless roads be built, and why should dustless roads be built?

We cannot hope to answer these questions with any degree of detail or exactness in this place, but it may be worth our while to give the subject a general kind of study.

The subject of dustless roads is not a new one. The dust nuisance has been recognized by cities for many years, and the city streets have been built with the thought in mind of having them yield as little dust as possible. Most cities also have watered, or otherwise treated their streets for many years to lay the dust where traffic has been heaviest, but not until within the last decade has much advance been made in the treatment of roads, other than city thoroughfares for the laying of dust. The automobile has been the chief agent whereby the advance along this line has been made. The amount of dust raised by teams is meagre in comparison with the amount raised by the swiftly moving automobile. Discomfort, danger to health, and damage to property along the dusty roads have each been a factor in influencing the public to rid themselves of this costly nuisance.

The public cannot hope to make any large percentage of the roads of a dustless nature, nor is that at present necessary, but the roads of the suburbs and the great public thoroughfares, which are daily receiving a large amount of traffic, especially by the automobile, must be treated to lessen the dust evil, if we are to work at all for our own and the public welfare.

Each community must settle for itself what roads should be treated to make them less dusty. The extent of the work is limited in the reverse ratio of wealth and enterprise of the people. This phase of the subject is not open, then, to discussion except to urge that the people fully awaken to the harmful effect to health and property of the dust and to bend every effort to eradicate the nuisance as far as possible.

There is no absolutely dustless road that will remain so for any great length of time, for if fine material does not come from the road itself it will, to some extent, come from extraneous localities. The term dustless must then be used in a relative sense and not in the absolute.

How can dustless roads be obtained is the question that most concerns the practical man. There are two possible methods.

Bituminous macadam road, penetration method. Birmingham, Ala. Rolling in the finishing coat of screenings; the view also shows heating tank for bituminous binder, and employment of convict labor.

1. By laying the dust that forms.
2. By preventing the formation of dust.

In the first method water or oil are added by some process to the dusty surface, and the dust particles are held by the surface tension or the cohesion of the liquid. The efficiency of this treatment varies largely with the viscosity of the liquid used and its liability to absorption or evaporation.

Water can be but temporary as it is highly volatile. The hygroscopic salts, those which have the power of gathering moisture from the atmosphere, as well as the lighter oils, are each also more or less temporary as dust layers.

In the second method the material used is such that its wear is very slight, or else it is composed of a substance which does not pulverize, and consequently does not yield dust. Here we deal either with the higher priced material for paving, such as brick, block, cement, etc., or else the heavier bituminous mixtures.

For the benefit of those who are contemplating either the palliation of dust on the roads or the construction of dustless roads, I shall attempt to brefly discuss some of the methods and materials used for this purpose.

The materials naturally group themselves, as already suggested, into those which are of a temporary nature and into those of a more lasting character. In the first class belong such materials as are effective for one season, or only a part of one season. Such materials are easily volatile in their nature, and, if one of the oils, has a low viscosity.

WATER.

For many years water was the only one of this class of dust layers which was used to any considerable extent, but with the introduction of oils the percentage of streets treated with water has considerably decreased. It is apparent that in some cases the true economic value of water as a dust layer has been lost sight of in the development of other dust palliatives. If the same study were given to the economical use of water that is now being given to oiling, the cost of using it would,

I am sure, be considerably lowered. Some of the more enterprising cities are now watering the streets from tank cars on their electric lines, thus greatly reducing the cost of application along those streets.

It is very difficult to get cost data concerning the use of water as a dust layer because of the lack of records, but an average of several records which are at hand, taken in different places in the country, shows an average cost of from two and one-half to four cents per square yard per season.

Hygroscopic Salts.

Hygroscopic salts which are produced in large quantities by some of the chemical establishments in this country, have been used to no small extent in various states, especially in those states where freight on the salt is not too excessive. The results, as a rule, have been successful. One of the hygroscopic salts which perhaps is used more widely than any other, is calcium chloride.

This class of dust layers can be placed on the road either in solution from a sprinkling cart, or else in a dry form by hand or machine. The amount used, in case of calcium chloride, is one and one-half pounds per square yard per treatment. The action of the salt is to gather moisture from the atmosphere, and one treatment is sufficient to supply moisture to the road sufficient for laying the dust for a period of from two to three months, depending of course on weather conditions. The cost per ton of the calcium chloride is about $13.00 F. O. B. at the manufacturers. The cost of spreading the material is small. In Washington, D. C., the cost per square yard per season for laying the dust by this salt was four cents in 1910. In Albany, N. Y., for the same year, it is estimated to have cost less than water.

There are practically no injurious results from the use of this salt, and where it can be as cheaply employed as water its use is preferable because of the less frequent interval of its application and the consequent less obstruction to traffic.

EMULSIONS.

The application of oily substances as dust layers, through the medium of emulsion, has been tried with varying success. Many experiments have shown emulsion to be highly economical and effective. Petroleum, tars, etc., are also miscible with water through the action of a saponifying agent, or soap.

Many kinds of emulsions are now manufactured. Their application is by means of the sprinkling cart.

*Cost data for emulsified road oils is here presented from a number of cities for the summer season of 1910:

Montclair, N. J., cost per square yard per season, less than water.

New London, Conn., cost per square yard, per season, 25 per cent. more than water.

Waltham, Mass., cost per square yard per season, 2 1-4c, water costs 3c.

Buffalo, N. Y., cost per square yard per season, 1.78c, on macadam.

Boston, Mass., cost per square yard per season, 1.7c., 8 applications.

Springfield, Mass., cost per square yard per season, 2c for 7 1-2 months.

"In binding the dust on the street pavements, experiments have been made in various parts of Berlin with a particular preparation, and according to official report a sprinkling with a 1 to 100 solution of this preparation and water, by means of ordinary street sprinklers, successfully kept the dust bound, even in the streets with the largest traffic, for four to five weeks. The cost per square meter (1.196 yards) for six oil solution sprinklings a year was less than one-seventh of the average annual cost for water sprinkling."

It will thus be seen that as a rule the general cost for treatment by emulsified oils is less than by sprinkling with water. There is also an accumulative beneficial effect provided the oil used is an asphaltic oil, so that the cost for the second year should be somewhat less than for the first.

*Data from Good Roads Magazine March and May, 1911.

HEAVIER BITUMINOUS MATERIALS.

Of the heavier bituminous materials which have been used in the United States in the past few years for bituminous road construction we have the following classes: fluxed native asphalts, oil asphalts, residual asphalts and semi-asphaltic oils, light oils, coke-oven tars, coal-gas tars and combinations of coal-gas tars and water-gas tars, combinations of asphaltic materials and tars.

The characteristics of these and also the definitions of many terms relative to the production of oils and residums is to be found in Circular No. 93 of the Office of Public Roads 1911. (See also bibliography of road literature in the appendix for further references.)

From the investigation of the last few years it is evident that refined coal tar is much to be preferred to the crude coal tar as a binder, it is also shown that crude water-gas tar is valuable only as a temporary binder and that its most satisfactory use is as a dust layer. Light applications of it should be sprinkled on the road whenever the dust becomes excessive.

The following table* shows the amounts of the three larger classes of bituminous binders used during 1908, 1909 and 1910 in eight of the states which have had the greatest amount of experience in the use of bituminous binders, viz.: Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania and Rhode Island:

Superficial Treatment of Roads.

	Tars and Tar-Asphalt Compounds.	Fluxed Native Asphalts, Oil Asphalts and Residual Asphaltic and Semiasphaltic Oils.	Light Oils.
1908	57,700 sq. yds.	239,500 sq. yds.	———
1909	95,500 sq. yds.	910,600 sq. yds.	4,125,900 sq. yds.
1910	123,400 sq. yds.	2,434,200 sq. yds.	9,890,400 sq. yds.

*Mr. A. H. Blanchard, Good Roads Magazine, April 1911.

Bituminous Pavements Constructed by Penetration Methods.

	Tars and Tar-Asphalt Compounds.	Fluxed Native Asphalts, Oil Asphalts and Residual Asphaltic and Semiasphaltic Oils.	Light Oils.
1908	37,800 sq. yds.	25,200 sq. yds.	———
1909	170,200 sq. yds.	2,077,400 sq. yds.	———
1910	339,300 sq. yds.	4,840,200 sq. yds.	26,500 sq. yds.

Bituminous Pavements Constructed by Mixing Methods.

	Tars and Tar-Asphalt Compounds.	Fluxed Native Asphalts, Oil Asphalts and Residual Asphaltic and Semiasphaltic Oils.	Light Oils.
1908	52,100 sq. yds.	4,400 sq. yds.	———
1909	136,000 sq. yds.	219,500 sq. yds.	———
1910	158,000 sq. yds.	432,600 sq. yds.	———

It is interesting to note from the standpoint of the general increase in the use of bituminous materials in the states cited that in 1908 bituminous materials were employed in the construction and maintenance of 416,000 square yards of road surface, in 1909 of 7,734 square yards and in 1910 of 18,244,000 square yards

The present tendencies as to the kind of bituminous binders used and the methods of applying them is briefly summarized by Mr. A. H. Blanchard in a paper read before the American Association for the Advancement of Science, 1910:

Surface Treatment.

"In the surface treatment of macadam and gravel roads several lines of development have been especially noticed: first, a more general use of refined coal gas and water gas tars in place of crude tars; second, an extraordinary increase in the various kinds of asphaltic oils, combined with sand, gravel or stone chips to form a carpet wearing surface; third, an increase in the use of light oils for the purpose of allaying dust on state roads and thus, to a certain extent, preserving the surface of the road by the retention of the top dressing;

fourth, a substitution of mechanical distributors of both the pressure and gravity flow type in place of hand application methods.

The practice of the past three years has amply demonstrated that the success of superficial tarring is dependent upon the recognition and adoption of those fundamental principles which were layed down by the French engineers in 1903. As those principles have not been adopted in many instances in the United States, they will be given here in brief. First, superficial tarring should be done only during dry and warm weather in order to obtain efficient and economical results; second, the road must have a dry, smooth and durable surface; third, all dust must be thoroughly brushed off in order to facilitate the adherence of the tar; fourth, after the distribution of the coat of tar it is necessary, in order to avoid a slippery surface, to apply a dressing of sand, gravel or stone chips. The practice of some prominent English engineers does not include the adoption of the fourth recommendation cited, as it is maintained that a top dressing is not an essential element of a non-slippery tarred surface.

A well developed plan of annually treating certain roads of a system with a thin coat of bituminous material is being adopted by certain states. This practice embodies the recognition of the fundamental principles of economy and efficiency in modern highway construction; namely, the adaptation of method and material to local conditions."

Penetration Method.

"In connection with the use of bituminous materials by penetration methods, certain noteworthy tendencies are apparent. Most important are the employment of distributing apparatus and the formation of broken stone courses in such a manner as to endeavor to secure the maximum uniformity of distribution of material and the definite limitation of penetration.

The unfortunate delay in the application of the penetration method due to damp stone, has been overcome in some in-

stances by the employment of mechanical surface heaters.

A modification of the penetration method is known as the "puddling method." The top course in this case is filled with screenings puddled by watering and thoroughly rolled. After the surface dries out it is picked up. The bituminous material is then applied, a coat of chips is spread and the surface rolled. After the surplus chips are brushed off, a flush coat of bituminous material is applied. The application of another coat of chips and a final rolling completes the process.

Another modification of the regular penetration method has been employed during 1910. In this method the foundation is thoroughly filled and rolled. A layer of sand is spread upon the foundation course to a depth of about an inch. Refined tar, heated to about 250° F. is then applied to the coat of sand. The top course, composed of broken stone varying from three-fourths to 2 3-4 inches is spread and rolled, the lower voids being filled with the bituminous mastic. After consolidation a second coat of refined tar is applied. As soon as possible after spreading the second coat of tar a layer of stone chips is spread and rolled. A third coat of refined tar is then applied and the surface finished by rolling a covering of screenings or sand."

Reconstructed Oil Roads.

"In the reconstruction of old roads there has been a general employment of the method of picking up the old surface to a depth of 2 inches to 4 inches by the use of mechanical scarifiers, placing a thin coat of new metal on the loosened surface, and then constructing a bituminous pavement by the penetration method.

In both the construction and reconstruction of roads by penetration methods the surface is finished in various ways. One method is to spread a coat of chips or sand after the first coat of bituminous material is applied, roll thoroughly, and after the road has set up sufficiently, open it to traffic. Another method is to apply a second coat of bituminous material be-

fore the application of a layer of chips. The bituminous material for the flush coat may or may not be the same as used for the first coat. A layer of chips or sand is then spread over the flush coat and thoroughly rolled. A third method is essentially the same as the second-cited except that a layer of chips is applied to the first coat of bituminous material, thoroughly rolled and the surplus chips brushed off before the application of the flush coat of bituminous material."

Character of Material Used.

"From the standpoint of the character of bituminous material used it is of special interest to note the increased use, particularly in 1909 and 1910, of fluxed natural asphalts and oil asphalts especially manufactured for application to unheated crusher run stone."

Mixing Method.

"In the construction of bituminous pavements by the mixing method a number of improvements and developments should be noted. Some attention has been paid to having the stone dry and reasonably clean. Although advantages accruing by using clean and dry stone are recognized, the practice has been far from satisfactory, only very crude methods having been thus far employed. The practice of heating stone on plates has been used to a certain extent with deleterious results. In a few cases mixing machines and tar coating machines have been employed in connection with the construction of bituminous pavements which are to cost not over $0.90 to $1.00 per square yard. The types of mixers which have been used to date are more or less unsatisfactory, especially when bituminous materials are used which are solid at ordinary temperatures or which flow with considerable difficulty when cold. During the season of 1911 considerable development should take place in the heating of stone by mechanical dryers and also in the use of new types of mixers especially manufactured for the purpose of mixing bituminous materials with a mineral aggregate..

In various parts of the United States sand, gravel and earth have been mixed in place by various processes with bituminous materials in the endeavor to form an impervious, dustless and durable road surface. This work is being watched with considerable interest as the utilization of local materials for the aggregate in many instances reduces the cost of construction materially. The limitation in the weight of traffic to be carried throughout the year under all climatic conditions is one of the most important points under discussion at the present time in connection with the above methods.

A new type of construction recently introduced by Logan Waller Page, director of the United States Office of Public Roads, is known as oil cement concrete. In this process fluid residual petroleum is added to the usual ingredients composing concrete.

From the standpoint of the nature of the materials used, again it is noted that there is an increase in the use of refined tar, considerable employment of heavy asphaltic compounds and also the employment of combinations of tar and asphalt, the most noticeable increase, however, being in the use of heavy asphaltic oils which can be mixed readily with broken stone as it comes from the crusher.

There has been a marked tendency on the part of highway engineers during the past three years to appreciate more fully the importance of the various chemical and physical properties of bituminous materials. Many engineers and manufacturers now wisely advocate using different grades of the same type of bituminous material for varying local conditions and for different methods of bituminous construction. During 1909 and 1910 bituminous materials for use in the construction and maintenance of roads have been purchased in two ways; namely, by buying direct from the manufacturer a product known under a trade name and by purchasing the material under specifications. The old custom of simply purchasing bituminous material under a trade name without investigation of its properties is being replaced by the second method. The object of the second method has been to cover one or more of the following points:

First, to secure uniformity in the material furnished for a given contract; second, to obtain a compound which conforms to certain requirements with reference to the chemical and physical properties of the material which are considered essential; third, to provide a standard by which it is hoped that a satisfactory material may be duplicated on other contracts. The effect of the various physical and chemical properties of bituminous materials on their value as road binders is being investigated by a special committee of the American Society of Civil Engineers. Standard methods of testing bituminous materials is the subject of investigation by a sub-committee of the American Society for Testing Materials."

The experiments of the U. S. Office of Public Roads during 1910 with bituminous binders is especially interesting. The results of these experiments are to be found in Circular No. 94 of that Office. The experiments conducted at Knoxville, Tenn., are perhaps of the greatest benefit to us, since the conditions there of labor and cost of materials are more nearly like our own than in places farther north and west. The work on the experimental roads at Knoxville began July 25 and ended September 7. The road constructed was bituminous macadam using the penetration method. The bituminous material was poured from coal scuttles fitted with strips of metal across the spouts so as to give an opening 4 1-2 inches across and 1-4 inch wide. The bituminous material was heated in two 120 gallon unmounted kettles, which was found to be a more expensive method than heating in kettles, where a fire box was used. Refined tar and oil asphalt were used on the respective sections. The foundation of the road was prepared from an old road which was very uneven. It was first spiked by a steam road roller then graded by a road machine, a spiked-tooth harrow was then run over the road bringing the larger stones to the surface and working the finer material down. Crushed limestone was next added, ranging from two inches to 3-4 inch in diameter to a depth of two inches then rolled until firm. A crown of 1-2 inch to the foot was adopted for both foundation and bituminous wearing surface. The labor employed was unskilled, consisting mainly of negroes. Common labor for foundation work

cost $1.35 per day of ten hours, and for bituminous work, $1.50 per day of ten hours. Double teams cost $3.50 and the roller and operator $3.00 per day. The analyses of the three preparations used were as follows:

Table Showing analysis of refined coal tar[1] *used in experiment No.* 1.

Specific gravity 25°/25° C	1.249
Float test at 32° C. (time)	1′ 47″
Float test at 50° C. (time)	44″
Per cent of free carbon (insoluble in CS_2, air temperature)	26.31

Distillation:

	Per ct. by vol.	Per ct. by w't.
Water	Trace.	Trace.
First light oils to 110° C	0.4	0.2
Second light oils 110°-170° C	[2] 2.2	1.6
Dead oils 170°-270° C	[3] 24.9	20.0
Pitch residue	[4] 72.5	77.7
	100.0	99.5

[1] Viscous, fluid, sticky. [2] Turbid. [3] Distillate showed about one-half its volume precipitated solids when cold. [4] Hard, brittle, dull fracture.

Table showing analysis of refined tar preparation[1] *used in experiment No.* 2.

Specific gravity 25°/25° C	1.244
Float test at 50° C. (time)	4′ 29″
Per cent of free carbon (insoluble in CS_2, air temperature)	17.13

Distillation:

	Per ct. by vol.	Per ct. by w't.
Water	0.0	0.0
First light oils to 110° C	.0	.0
Second light oils 110°-170° C	[2] .4	.3
Dead oils 170°-270° C	[3] 23.2	18.8
Pitch residue	[4] 76.4	80.4
	100.0	99.5

Table showing analysis of oil-asphalt[5] used in experiment No. 3.

Specific gravity 25°/25° C	0.998
Penetration (No. 2 N, 5 seconds, 100 grams, 25° C.)	86°
Per cent of gain at 163° C., 5 hours (20 grams)	0.02
Penetration of residue[6] (as above)	75°
Per cent of total bitumen insoluble in 86° B. paraffin naphtha	22.88
Per cent of fixed carbon	13.78
Per cent of bitumen soluble in CS_2, air temp. (total bitumen)	99.85
Organic matter insoluble	.10
Inorganic matter	.05
	100.00

[1] Very viscous, sticky. [2] Clear. [3] Distillate showed about two-fifths its volume precipitated solids when cold. [4] Hard, fairly lustrous. [5] Semisolid, sticky. [6] Slightly harder, otherwise unchanged.

THE FOLLOWING IS THE TABLE SHOWING THE COST DATA IN CONDENSED FORM FOR THE THREE STRIPS OF EXPERIMENTAL ROAD:

Section No.	Description.			Quantity of material.				Cost data (cents per square yard).										Total cost—			
	Binding materials.	Length of section (feet).	Area of section (square yards).	No. 2 stone (cubic yards per square yard).	Screenings (cubic yards per square yard).	Binder, first application (gallons per square yard).	Binder, second application (gallons per square yard).	No. 2 stone at crusher.	Screenings at crusher.	Handling and laying stone.	Binder.	Hauling binder.	Heating and applying binder.	Rolling.	Grading.	Miscellaneous.	Freight on binder.	Cents (per square yard).	Entire section.	Foundation and wearing surface (cts. per sq. yd).	Entire section—foundation and wearing surface.
1-3	Foundation	980	2,198	0.054	......	......	......	[8]6.48	......	1.72	......	......	......	1.23	3.72	......	......	13.15	$289.04	......	......
1	Refined coal tar	217	482	.117	0.022	1.49	0.50	7.90	1.48	8.90	21.89	0.36	2.78	1.27	......	2.31	0.00	46.89	226.01	60.04	$289.39
2	Refined tar preparation	590	1,311	.117	.022	1.21	.50	7.90	1.48	8.90	10.26	.19	3.24	.80	......	2.31	5.75	40.83	535.28	53.98	707.68
3	Oil-asphalt	173[7]	.405	.117	.022	1.69	.50	7.90	1.48	8.90	16.10	.00	2.96	.91	......	2.31	.00	40.56	164.27	53.71	217.53

[7] Includes intersection of Lake Street. [8] No. 2 Stone at siding.

It will be noticed that the cost ranges from about 53 to about 60 cents per square yard, including all expenses on foundation and materials.

During the year 1910 extensive experiments were also carried on at Ithaca, N. Y. Here as at Knoxville an old road was spiked up, graded and treated with broken stones which when rolled was about 2 1-2 inches thick. Three different methods were used, viz: 1st, the penetration method; 2nd, the prepared filler method, which may be described as one in which the wearing course of stone is bound with a filler composed of a mixture of stone screenings and bitumin and, 3rd, the mixing method. The expenses connected with the construction of the road for labor and material is somewhat in excess of that at Knoxville, Tenn. Labor cost $1.75 for a nine hour day and double teams $4.00 per day. The cost of construction was, as in the case of the experiment at Knoxville, rather excessive owing to the shortness of the sections and the crude machinery and heating apparatus. The different bituminous materials used were as follows: oil asphalt, refined asphaltic preparation, refined semiasphaltic oil, refined water-gas tar.

The following tables show the cost data for the different materials used in the three methods: 1. The penetration method. 2. The prepared filler; and 3, the mixing method. It will be seen that the total cost per square yard for the penetration method ranges from 63 cents to 79 cents, for the prepared filler method, from 82 cents to 92 cents, and for the mixing method from 91 cents to $1.13. For details of the various experiments at Ithaca, see Circular 92 and 94 of the Office of Public Roads.

Table showing materials and cost data of experiments at Ithaca, N. Y., 1910.

PENETRATION METHOD.

Description.				Quantity of materials.								Cost data (cents per square yard).												Total cost—			
Binding materials.	Course.	Length of section (feet).	Area of section (square yards).	No. 2 stone (cubic yards per square yard).	Screenings (cubic yards per square yard).	Binder, first application (gallons per square yard).	Bonder, second application (gallons per square yard).	Screenings used on stone shoulders (cub. yds. per sq. yard).	Sand used on shoulders (cubic yards per square yard).	Sand filler (cubic yards per square yard).	3-4 inch stone used (cubic yards per square yard).	No. 2 stone at siding.	3-4 inch stone at siding.	Screenings at siding.	Hauling and laying stone.	Binder.	Hauling binder.	Heating and applying binder.	Rolling.	Miscellaneous.	Freight on binder.	Grading.	Hauling and spreading sand.	Cents (per square yard).	Entire section.	Foundation and wearing surface (cents per sq. yards).	Entire section—foundation and wearing surface.
Oil-asphalt..........	Foundation......	300	667	0.042	.....	.....	.....	0.025	.....	.....	.....	6.34	....	3.17	5.29	.....	.....	.....	3.09	1.30	.....	4.28	....	23.47	$156.55	} 79.10	$421.61
Oil-asphalt..........	Wearing surface	300	533	.113	0.021	1.00	0.50	.....	.....	.....	.....	17.06	....	3.17	5.78	11.25	1.90	1.35	5.01	1.62	2.09	....	....	49.73	265.06		
Refined asphaltic preparation.	Foundation......	252	586	.....	.....	.....	.....	.025	0.016	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.09	1.30	.....	4.28	0.03	8.70	50.08	....	....
.....do..............	Wearing surface	106	308	.100	.034	.80	.80	.....	.....	0.021	0.024	15.10	3.62	5.13	8.19	18.40	1.01	6.76	5.01	1.62	3.70	....	.03	69.36	213.63	78.34	241.28
.....do..............	.....do............	146	260	.100	.034	.80	.00	.....	.....	.021	.024	15.10	3.62	5.13	8.98	9.20	.51	3.38	5.01	1.62	1.85	....	.03	54.43	141.52	63.40	164.36

Table showing materials and cost data of experiments at Ithaca, N. Y., 1910.—Continued.

PREPARED-FILLER METHOD.

Section No.	Description.				Quantity of materials.								Cost data (cents per square yard).											Total cost—			
	Binding materials.	Course.	Length of section (feet).	Area of section (square yards).	No. 2 stone cubic yards per square yard).	Prepared filler, first application (cubic yards per sq. yard.)	Prepared filler, second application (cubic yds. per sq. yd.)	Screenings (cubic yards per square yard).	Binder in mixture, first application (gallons per sq. yd).	Binder in mixture, second application (gals. per sq. yd.	Binder in paint coat (gallons per square yards	Screenings used on shoulders (cubic yards per sq yd).	No. 2 stone at siding.	Mixed stone at siding.	Screenings at siding.	Binder.	Hauling and laying No. 2 stone.	Preparing and laying mixture.	Heat'g and applying paint coat.	Freight on binder.	Rolling.	Miscellaneous.	Grading.	Cents (per square yard).	Entire section.	Foundation and wear'g surface. Basis of wearing surface (cts. per square yard).	Entire section—foundation and wearing surface.
17	Oil-asphalt....	Foundation	50	111	0.042	.....	.....	.....	.....	.....	.....	0.025	6.34	.....	3.17	.....	5.29	.....	.....	.....	3.09	1.30	4.28	23.47	$26.05	83.69	$74.48
17	......do.........	Wearing surface ..	50	89	.111	0.042	.....	0.021	0.90	.....	0.50	.....	16.76	6.34	3.17	10.50	5.78	3.40	1.50	1.93	5.01	.....	.....	54.42	48.43		
19	......do.........	Foundation	76	169	.049	.....	.....	.....	.....	.....	.....	.025	7.40	.....	3.17	.....	5.85	.....	.....	.....	3.09	1.30	4.28	25.09	42.40	92.34	124.66
19	......do.........	Wearing surface ..	76	135	.111	.055	0.014	.021	.98	0.25	.....	.....	16.76	10.42	3.17	14.15	3.37	5.59	.....	2.46	5.01	.....	.....	60.93	82.26		

Table showing materials and cost data of experiments at Ithaca, N. Y., 1910.—Continued.

MIXING METHOD.

Description.				Quantity of material.					Cost data (cents per square yard).													Total cost—			
Binding materials.	Course.	Length of section (feet).	Area of section (square yards).	No. 2 Stone (cubic yards per square yard).	Mixed stone (cubic yards per square yard).	Screenings (cubic yards per square yard).	Binder in mixture (gallons per square yard).	Binder used in paint coat (gallons per square yard.	Screenings used on stone shoulders (cubic yds. per sq. yd.	No. 2 stone at siding.	Stone used in mixture at siding.	Screenings at siding.	Hauling and laying stone.	Binder.	Hauling mixture.	Preparing and laying mixture.	Heating and applying paint coat.	Rolling.	Miscellaneous.	Freight on binder.	Grading.	Cents (per square yard).	Entire section.	Foundation and wear'g surface. Basis of wearing surface (cts. per square yard).	Entire section—foundation and wearing surface.
Oil-asphalt	Foundation	300	667	0.049	.....	.....	.....	.....	0.025	7.40	.....	3.17	5.85	.....	.....	.....	....	3.09	1.30	....	4.28	25.09	$167.35	} 113.58	$605.87
......do	Wearing surface	300	583	.....	0.119	0.021	0.88	0.55	.....	.....	17.97	3.17	....	16.45	3.37	29.60	2.13	5.01	1.62	2.86	....	82.18	438.02		
Refined semiasphaltic oil.	Foundation	300	667	.054	.....	.....	.....	.....	.025	8.15	.....	3.17	6.24	.....	.....	.....	....	3.09	1.30	....	4.28	26.23	174.95	....	....
......do	Wearing surface	206	366	.....	.118	.021	.83	.55	.....	.....	17.06	3.17	....	9.66	4.83	26.98	2.17	5.01	1.62	1.99	....	72.49	265.32	105.32	385.45
......do	...... do	94	167	.....	.113	.021	.83	.00	.....	.....	17.06	3.17	....	5.81	4.83	26.48	.00	5.01	1.62	1.20	....	65.18	108.85	98.00	163.66
Refined water-gas tar	Foundation	300	667	.046	.....	.....	.....	.....	.025	6.95	.....	3.17	5.61	.....	3.83	.....	....	3.09	1.30	....	4.28	24.40	162.75	....	....
......do	Wearing surface	130	231	.....	.119	.021	.88	.55	.....	.....	17.97	3.17	....	10.01	3.83	17.29	1.17	5.01	1.62	2.77	....	62.84	145.16	93.87	215.70
......do	do	170	302	.....	.119	[1] .017	.88	[1] .13	.....	.....	17.97	2.57	....	7.04	4.38	19.76	.00	5.01	1.62	1.96	....	60.34	182.23	90.87	274.44
Oil-asphalt	Foundation	296	658	.046	.....	.....	.....	.....	.025	6.95	.....	3.17	5.61	.....	.....	.....	....	3.09	1.30	....	4.28	24.40	160.55	} 102.78	540.64
......do	Wearing surface	296	526	.....	.132	.021	.98	.55	.....	.....	19.93	3.17	....	15.30	3.43	18.42	1.47	5.01	1.62	3.91	....	72.26	380.09		

[1] Mixed for surface binder.

The experience in bituminous macadam road construction in R. I. in 1909 by the mixing method shows the following cost data: average cost of the macadam road without binder 54.1c. per square yard; for extra bituminous construction, materials and labor about 37c. per square yard, giving an average cost of about 91c. per square yard for the completed road. The cost for mixing by hand varied from 4c. to 6c., and the cost for applying the flush coat varied from one to one and one-half cents per square yard. The amount of bituminous material used per square yard was on an average of two and one-half gallons.

It may be said in general that the cost of using a bituminous binder on a macadam road is, in the case of the penetration method about 25c. and in the case of the mixing method about 35c. over and above the cost of ordinary macadam construction.

One of the most successful moves made in the past few years for the laying of dust and the maintenance of the road surface is that brought about through the use of bituminous binders with the local materials such as sand gravel and earth. Roads made of such mixtures have given splendid service and the continuance of this custom means the growth of many of our suburban districts. The cost for thus treating a road is much less than the cost for the construction of a bituminous macadam and under the light traffic the results would be in many ways equally as satisfactory. In Massachusetts where a large amount of road has been built of this nature, a good grade asphaltic oil is used with a sandy gravel. Two layers of one-half gallon per square yard each are used and sand to a thickness of one inch is rolled into each layer. The cost per mile for a width of 15 feet varies from $1,800 to $2,000.

It is very difficult to say which of the processes of using the bituminous binder, by the mixing or by the penetration methods is the better. Both of the processes have their ardent adherents. In this question, as in all similar questions, circumstances must be taken into account. It seems to be the general opinion of engineers, at the present time, however, that uniformly better results are obtained by the mixing process than by the penetration process, provided the stone and

binder are properly handled, but that the mixing method is too expensive unless machinery of suitable character can be employed in the mixing. When the binder is applied to the road in the penetration method better results seem to be had when this application is made from machine with liquid under considerable pressure. In the construction of the roads in Mass., where the penetration method is employed very largely with good results, a pressure of from 75 to 100 pounds per square inch on the liquid is employed.

Oil Cement.

The experiments with oil-cement concrete which were tried by the Office of Public Roads in a few experiments in 1909 were more extensively carried on during 1910. It is yet too early to predict the economical use of this mixture, but the results as far as they have been observed, are very favorable.

A fluid oil, either a fluid residual petroleum of a cut-back petroleum residue, has been employed. Such oils have been added to a cement mortar to an amount equal from 10 to 20% of the weight of the cement used. In the experiments in Washington, D. C., the cement thus prepared was applied to a foundation which was constructed in two courses of from one-half inch to one and one-half inches broken stone placed to a depth of five inches loose upon the prepared sub-grade, and which after rolling had received screenings from one-half inch in diameter to dust, and had been finished as in ordinary macadam road work. The thickness of the oil cement concrete used was equal to about an inch and a half to two inches which was either placed upon the foundation and then covered wth about two and one-half inches of broken stone and rolled until the voids in the broken stone were entirely filled with the oil cement concrete, or else the broken stone was first added and mixed with the oil concrete and then applied to the road and tamped until the voids were filled. In the seven experiments conducted varying amounts of oil cement stone and sand were used so as to discover if possible the best percentage of each. The cost data of these experiments which follows shows a range of from $1.15 to $1.25 per square yard for the total cost.

Table showing materials and cost data of experiments with oil-cement-concrete at Washington, D. C., 1910.

Section No.	Description.			Quantity of materials.					Cost data (cents per square yard).							Total cost—	
	Oil.	Length of section (feet).	Area of section (square yards).	Stone (cubic yards per square yard).	Screenings (cubic yards per square yard).	Sand (cubic yards per square yard).	Cement (cubic yds. per square yard).	Oil (gallons per square yard).	Stone at mixer.	Screenings at mixer.	Sand at mixer.	Cement at mixer.	Oil at mixer.	Mixing and laying concrete.	Foundation and miscellaneous.	Cents (per square yard).	Entire section.
7	Fluid residual petroleum	65.8	142.6	0.063	......	0.037	0.015	0.534	15.75	......	6.75	14.18	4.01	24.20	52.52	117.41	$167.43
6	...... do	24.3	52.6	.047	......	.024	.018	.640	11.75	......	6.00	17.01	4.80	23.05	52.52	115.13	60.56
5	...... do	45.0	97.5	.047	0.036	......	.018	.640	11.75	9.00	......	17.01	4.80	23.05	52.52	118.13	115.18
4	...... do	37.0	80.2	.047	.024	.012	.018	.960	11.75	6.00	3.00	17.01	7.20	23.05	52.52	120.53	96.67
3	Cut-back pertoleum residue	68.0	147.3	.047	.024	.012	.018	.937	11.75	6.00	3.00	17.01	12.18	23.05	52.52	125.51	184.88
2	...... do	72.4	156.9	.047	.024	.012	.018	.625	11.75	6.00	3.00	17.01	8.13	23.05	52.52	121.46	190.57
1	None	39.4	85.4	.047	.024	.012	.018	......	11.75	6.00	3.00	17.01	......	23.05	52.52	113.33	96.78

THE COST DATA FOR OTHER EXPERIMENTS CONDUCTED IN NEW YORK CITY DURING 1910 BY THE OFFICE OF PUBLIC ROADS WITH THE SAME MATERIALS ARE SEEN IN THE FOLLOWING TABLE:

Table showing materials and cost data of experiments with oil-cement-concrete at New York, N. Y., 1910.

Section No.	Description.			Quantity of material.				Cost data (cents per square yard).						Total cost—	
	Oil.	Length of section (feet).	Area of section (square yards).	Stone (cubic yards per square yard).	Sand (cubic yards per square yard).	Cement (cubic yds. per square yard).	Oil (gallons per square yard).	Stone at mixer.	Sand at mixer.	Cement at mixer.	Oil at mixer.	Mixing and laying concrete.	Prepar'g foundation and miscellaneous.	Cents (per square yard).	Entire section.
1	Fluid residual petroleum	163	580	0.123	0.062	0.031	1.61	18.45	7.13	27.62	12.07	21.78	2.28	89.33	$578.11
2	...... do	77	274	.123	.062	.031	1.07	18.45	7.13	27.62	8.02	21.78	2.28	85.28	233.67
3	Cut-back petroleum residue	100.5	357	.123	.062	.031	1.88	18.45	7.13	27.62	24.44	21.78	2.28	101.70	363.07
4	...... do	108.5	368	.123	.062	.031	1.88	18.45	7.13	27.62	24.44	21.78	2.28	101.70	374.26

The total cost per square yard in the above is slightly less than the cost for the experimental roads built in Washington, D. C., the cost here being from about 85c. to $1.01.

Another experiment with oil-cement concrete was carried on at Bridgewood, N. J., in 1910. This experiment differed from the others in that the oil-cement was placed upon the other concrete layer while the lower one was still fresh and soft, thus assuring a perfect bond between the two. In this experiment the average thickness of the whole concrete layer was five and one-half inches, the upper one and one-half to two inches only containing the oil.

Rock Asphalt.

Another important material that has come into use quite extensively in the last few years is native rock asphalt. This material is a sandstone which has received a deposit of bituminous material through the percolation of bituminous bearing oils or gases through it in former times. The bituminous matter is found coating the grains of the sandstone and in some cases in quantity sufficient to nearly fill the voids in the stone. In general the percentage of the bituminous material does not run over 7-8% of the mass of the rock. The Kentucky rock asphalt has been considerably used for the purpose of constructing dustless roads. A test road made by the U. S. Office of Public Roads in 1907 in Bowling Green, Ky., was inspected in December, 1910, and found to be in good condition, "the cross section was well maintained; and the surface rang sharply under the blows of horses hoofs." The stone was thoroughly bonded and showed no sign of raveling. "A small specimen of the rock asphalts when dug up and warmed in the hand showed that the bitumen still had considerable life." See circulars: 89, 90, 92 and 94 of Office of Public Roads, for the particulars of this experiment.

In regard to the purchase of bituminous materials it may be said that the cost alone may have but small influence upon the suitability of the material for the particular work in hand. It should always be the rule to have the materials tested and

to buy such materials only as will satisfy the tests essential for that particular class of work. The office of Public Roads has made a great many tests of materials and stands ready to advise as to the specifications necessary for different classes of work and different localities. It is hoped that the State Testing Laboratory also will soon be in shape to handle and report on bituminous binders as well as upon the other road building materials for which it is now equipped.

TABLE GIVING AMOUNT OF OIL REQUIRED FOR ONE MILE OF ROAD.

Of Various Widths and in Varying Quantities per Square Yard.

Width.	Sq Yds.	Amt. per Sq. Yd.	Gallons.
8 Feet	4693	¼ Gal.	1173
8 Feet	4693	⅓ Gal.	1564
8 Feet	4693	½ Gal.	2347
8 Feet	4693	¾ Gal.	3550
8 Feet	4693	1 Gal.	4693
8 Feet	4693	1½ Gal.	7040
10 Feet	5866	¼ Gal.	1464
10 Feet	5866	⅓ Gal.	1956
10 Feet	5866	½ Gal.	2933
10 Feet	5866	¾ Gal.	4400
10 Feet	5866	1 Gal.	5867
10 Feet	5866	1½ Gal.	8800
12 Feet	7040	¼ Gal.	1760
12 Feet	7040	⅓ Gal.	2347
12 Feet	7040	½ Gal.	3520
12 Feet	7040	¾ Gal.	5280
12 Feet	7040	1 Gal.	7040
12 Feet	7040	1½ Gal.	10560
14 Feet	8213	¼ Gal.	2053
14 Feet	8213	⅓ Gal.	2738
14 Feet	8213	½ Gal.	4107
14 Feet	8213	¾ Gal.	6160

Width.	Sq. Yds.	Amt. per Sq. Yd.	Gallons.
14 Feet	8213	1 Gal.	8213
14 Feet	8213	1½ Gal.	12310
16 Feet	9386	¼ Gal.	2347
16 Feet	9386	⅓ Gal.	3129
16 Feet	9386	½ Gal.	4693
16 Feet	9386	¾ Gal.	7040
16 Feet	9386	1 Gal.	9387
16 Feet	9386	1½ Gal.	14080
18 Feet	10560	¼ Gal.	2640
18 Feet	10560	⅓ Gal.	3520
18 Feet	10560	½ Gal.	5280
18 Feet	10560	¾ Gal.	7920
18 Feet	10560	1 Gal.	10560
18 Feet	10560	1½ Gal.	15840

From Standard Oil Co.'s Standard Road Oil Bulletin.

LOCATION OF ROADS.

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The considerations governing the location of country roads are dependent upon the commercial conditions of the country to be traversed.

In well settled and long-inhabited sections the controlling element will be the character of the traffic to be accommodated. In such a section the route is generally predetermined, and there is less liberty of choice of route than in a new and sparsely settled district, where the object is to establish the easiest, shortest, and most economical line of intercommunication according to the physical character of the ground.

The determination of the best location for a road requires a study of the topographical features of the region through which the road is to pass, and also an investigation of the nature and extent of the traffic to be provided for.

Only in new and unsettled sections of country does the problem arise of locating long stretches of highway. Throughout Alabama roads already exist between all of the principal towns and villages. Many of these roads were built before the advent of railroads and form a system of intertown routes. While some of these ways were laid out with considerable engineering skill, most of them were located with no apparent regard to the topography. When the location of a road is once determined and farms and villages have been established along the way, the problem of improving such a road reduces itself to making the best grade without departing any more than possible from the old location. To relocate entirely such a road would evidently be out of the question, for it would not meet the needs of the community which it now serves. In order to meet the demands of modern traffic it will frequently be necessary to locate new highways or relocate old roads where lack of alignment or the unfavorable grades of the latter precludes the construction of an easy and fast way, such as is demanded by the motorist.

The necessity for the location of new roads will not often arise; and hence the only application of the principles of economic location will be in the re-location of comparatively short stretches of road. The original location may have been entirely satisfactory when the region was new and undeveloped, but the increase in the amount and the change in the character of the traffic may justify a very considerable change. It is probably not overstating the situation to assert that most of the principal highways in Alabama could be materially improved by careful re-location.

In locating a new road it should be remembered that the location will probably serve for many generations, and perhaps for all time, as the growing importance of the surrounding territory and the location of buildings and of division lines of the land with reference to the road make it increasingly more difficult and expensive to change the location.

"The location of a road is the field where costly errors and permanent blunders may creep in and forever fasten themselves upon the road and its users; and worst of all, these errors become more costly as the use of the road increases.

"Viewed as a question of economics, the best location is that for which the sum of the interest on the cost of construction and of the annual cost of maintaining the road and of conducting transportation over it, is a minimum."

The location of a wagon road is not however, entirely a question of economics, since the location should be made with reference to the convenience, comfort and perhaps the pleasure of those who use it; and it is frequently more of a social or political question than one of economics. It is the purpose to consider here only the economic features of location in brief form.

The principles to be observed and the methods to be employed in making the location of a wagon road are substantially the same as those used in the location of a railroad. The methods adopted in making surveys and plans for the improvement of public highways in New York State are fully described by C. W. Trumbull, Division Engineer in Bulletin No. 10 issued July, 1905, by the Department of the State En-

gineer and Surveyor. The method of examining the country and of making surveys will not be considered here, as such subjects fall within the province of the engineer and are elaborately presented in treatises on railroad location.

Selecting the Route.

Byrne in his treatise on Highway Construction lays down the following principles to be observed in making final selection:

"In making the final selection the following principles should be observed as far as practicable:

(a) To follow that route which affords the easiest grades. The easiest grade for a given road will depend upon the kind of covering adopted for its surface.

(b) To connect the places by the shortest and most direct route commensurate with easy grades.

(c) To avoid all unnecessary ascents. When a road is encumbered with useless ascents, the wasteful expenditure of power is considerable.

(d) To give the center line such a position, with reference to the natural surface of the ground, that the cost of construction shall be reduced to the smallest possible amount.

(e) To cross all obstacles (where structures are necessary) as nearly as possible at right angles. The cost of skew structures increases nearly as the square of the secant of the obliquity.

(f) To cross ridges through the lowest pass which occurs.

(g) To cross either under or over railroads; for grade crossings mean danger to every user of the highway. Guards and gates frequently fail to afford protection, and the daily press is filled with accounts of accidents more or less serious; and while statistics fail to give total casualties, the aggregate must be great."

Among the more important factors that govern the location of a road, and which are applicable to either a long or short piece, are the items: distance, grades, curves, width and final alignment, which will be considered in detail.

DISTANCE.

With the terminals of a road given, the general direction is ordinarily fixed. Other things being equal, the shorter the road the better, since any unnecessary length causes a constant and threefold waste: (1) the interest on the cost of constructing the extra length; (2) the ever-recurring cost of repairing it; and (3) the time and labor employed in traveling over it. The advantage of straightness, except in perfectly flat country, is likely to be greatly overestimated. "One of the most common defects of ordinary country roads is that distance has been saved by a disregard of the desirability of easy gradients. The curving road around a hill may often be no longer than the straight one over it; for the latter is straight only with reference to the horizontal plane, but curved as to the vertical plane, while the former is curved as to the horizontal plane, but straight as to the vertical plane. Both lines curve, and the one passing over the hill is called straight only because its vertical curvature is less apparent to the eye."

Consider the case of two towns situated on the same side of a valley. A road following a direct line between them may be laid out which will gradually and equally incline from one town to the other, supposing them to be at different levels, or which will keep at the same level throughout the entire course, if the two towns be on the same level; or a line may be adopted which will gradually and equally incline from one town to the other following all the sinuosities and curves which the irregular formation of the country may render necessary for the fulfillment of these conditions. The first line would cross all the valleys and streams, necessitating deep cuttings, heavy embankments and possibly numerous bridges; the second line would avoid these expensive works by following the sinuosities of the valley. When the sides of the valley are pierced by ravines with projecting spurs and ridges intervening, instead of following the sinuosities, it will be found better to make a nearly straight line cutting through the projecting points in such a way that the material excavated will be just sufficient to fill the hollows. Now, of the above

routes, the best is the straight and uniformly inclined, or the level road, although at the same time it is the most expensive. If the conditions or importance of traffic passing between the places is not sufficient to warrant so great an outlay, it will become a matter of consideration whether the course of the road should be kept straight, its surface being made to undulate with the natural face of the country; or whether a level or equally inclined line being adopted, the course of the road should be made to deviate from the direct line and follow the winding course which such a condition is supposed to necessitate.

If the two towns were situated on opposite sides of a main valley, the case would afford the same choice of a perfectly straight line with uniform grade or a winding route with practically uniform grade; the former would probably be very expensive while the latter might be very much longer.

A third condition is afforded where two towns are located in different valleys, separated by an intervening ridge more or less elevated. In this case, there is also the alternative of carrying the road across the intervening ridge in a perfectly straight line, or deviating to the right or left, and crossing the ridge at a point where the elevation is less. The proper determination of the question which of these courses is the best under the circumstances involves a consideration of the values and comparative advantages and disadvantages of inclines and curves, which will be considered later.

Value of Saving Distance.

The value of a difference in length may be computed by determining (1) the amount of traffic passing over the given road, (2) the cost per ton-mile, and (3) the total cost of conducting the traffic; "and then assuming that the value of any difference of length is to the total cost of transportation as the difference of length is to the total length. If the annual cost of conducting transportation over a given road is known, then this cost divided by the length of the road gives the annual interest upon the sum that may be reasonably expended

in shortening the road one mile, i. e., the value of a saving of a mile of distance; and of course dividing this sum by the number of feet in a mile will give the value of saving one foot of distance."

In Circular No. 19 published under date of April 4, 1896, by the Road Inquiry Office of the United States Department of Agriculture, the cost of wagon transportation in Alabama is given at $0.25 per ton mile; average cost per ton, $3.13; average load, 1,383 pounds; average haul in miles, 12.77. The above statistics were based upon replies received by the Department of Agriculture from only 23 counties in the State, and the price fixed, i. e., 25 cents per ton mile cannot be regarded as reliable. It is practically impossible to determine the amount of traffic on our wagon roads with any considerable degree of accuracy from existing records. Any estimate as to the value of a saving of distance, except cost of construction which can be accurately determined, is necessarily only a rough approximation and should be used only as a guide to the judgment.

Grades.

The grade of a road is expressed in the number of feet of rise in one hundred feet of horizontal distance. A road with one foot rise in one hundred feet of length is said to have a grade of one per cent; a road of two feet rise a grade of two per cent, etc.

While a level road is the most desirable it can seldom be obtained. The problem therefore reduces itself to securing as nearly as practicable a level road and to investigating the effect of grades upon the cost of constructing and operating the road, and also to determine the limiting gradients.

Perhaps the greatest improvement that can be made in a road is to lessen the grades. This may be accomplished (1) by going around the hill or by zigzagging up the slope, or (2) by cutting down the hill. If the slope to be ascended is a long one, the first method must be employed; but if the grade is short, the second is usually cheaper. Increasing the length

adds to the cost of construction and of transportation, while cutting down the hill adds only to the cost of construction. The maintenance of the longer and flatter line may cost either more or less than the shorter and steeper one according to the circumstances in the case. In a broken or rough country, a proper adjustment of the grades is the most important part of the art and science of road building; and the better the road surface the more necessary is such an adjustment."

"All grades are objectionable for two distinct reasons, viz: Because a grade increases the amount of power required to move a load up it, and because a grade may be so steep as to limit the amount of the load that can be moved over the road. The first applies to all grades whatever their rate or height; while the latter applies only to the steepest grade on the road, and in a measure is independent of its height and depends only on its rate."

Power of a Horse.

(From Bakers' Roads and Pavements.)

"The horizontal pull which a horse can exert depends upon its weight, its form or build, the method of hitching, the foothold afforded by the surface, the speed, the length of duration of the effort, the rest time between efforts, and the tax upon the future efficiency of the horse. The chief of these are the weight, the speed, and the length of the effort. With reasonably good footing a horse can exert a pull equal to one-tenth of his weight at a speed of 2 1-4 miles an hour (3 2-3 feet per second) for ten hours per day of six days per week and keep in condition. This is a common rate of exertion by farm horses in pulling plows, mowers, and other agricultural implements. Most horses can exert a tractive power equal to one-half their weight, at a slow walk about one hundred feet. On the road in emergencies, as in starting the load or in overcoming obstacles, a horse may be expected to exert a pull equal to half his weight, but at this rate he would develop a day's energy in about two hours; and consequently if he is expected to work all day, he should not be called upon to ex-

ert his maximum power except for a short time. Similarly, a horse can exert a draft equal to one-quarter of his weight for a longer time. The working tractive power of a horse may be taken as one-tenth of his weight, with an ordinary maximum of one-quarter, and in great emergencies a maximum of one-half his weight."

The following table compiled from Bulletin No. 52 of the Missouri Agricultural Experiment Station gives data of very practical experiments on the amount of pull exerted in drawing a load of constant weight over various kinds and conditions of roads and fields. In the experiments they used the same load upon two different sets of wheels: standard size with 44 inch front and 55 inch rear wheels, and the low size with 24 inch front wheels and 28 inch rear wheels. The wheels were of steel construction with six inch tires, and the difference in weight was such that the total weight of wagon and load with the high wheels was 3,762 pounds and with low wheels 3,362 pounds.

TABLE.

Kind of Road.	Condition of Road.	Number of pounds pull.	
		High Wheels.	Low Wheels.
Gravel road	Level, dry, with one inch of sand and some loose gravel	158.9	185.2
Macadam street	Clean and in fair condition	108.0	117.4
Cinder track	Dry and not firm	113.1	120.0
Dirt road	Frozen solid, one-half inch sticky mud on top	189.2	233.8
Timothy and blue-grass sod	Dry and hard, in good condition	130.0	132.0
	Dry and firm, level	248.1	300.6
Corn stubble	Dry, with small ridges	335.7	445.6
Plowed ground	Freshly plowed and dry	475.0	628.0

"This table gives the pull necessary to draw the wagon and a net load of two thousand pounds over the surfaces named. If the pull be taken as one-tenth the weight of the team, according to the above quotation from Baker, to pull the loads used in these experiments on gravel roads would require a team weighing 1,589 pounds with the standard wheels and 1,853 pounds with the low wheels.

On macadam the team would only need to weigh 1,080 pounds. On the plowed ground, however, with standard wheels it would take a team weighing 4,750 pounds to pull this load with the ordinary effort which should be required of a horse. Even supposing the team were to exert for a short distance a pull equal to one-quarter of its weight, it would need to weigh 1,900 pounds. The results in the above table were obtained from experiments conducted on level ground. If it were desired to pull these loads up grade the pull would, of course be much greater."

According to Baker, if a horse can pull 1000 pounds on a muddy level road it can pull

2000 pounds in spongy earth roads,
3000 pounds on best earth roads,
6000 pounds on macadam roads,
10,000 pounds on asphalt,
20,000 pounds on iron rails.

The following Table, arranged from Baker, gives the percentage of the load for level ground which a horse can pull up grades of different degrees of steepness.

Table showing load which a horse can draw on a grade in terms of percentage of the load on the level, when exerting a uniform force equal to one-tenth of its weight.

Rate of grade per cent.	Iron rails	Sheet Asphalt.	Broken stone.	Earth Road.		
				Best.	Spongy.	Muddy.
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
0	100	100	100	100	100	100
1	30	45	56	62	75	91
2	16	27	36	50	57	67
3	10	18	25	37	44	54
4	7	12	17	27	33	43
5	4	8	12	20	25	33
6	3	6	8	14	18	25
7	2	4	6	10	12	18
8	1	2	4	6	8	11
9	1	1	2	3	4	5

From this table appears the important fact that the smoother and harder the road is the more gentle the grades must be. On a muddy road for instance, a horse can draw 91% on a one per cent. road of what he can draw on a level road of the same kind. On the best earth road he can draw 62% and on macadam on 56%. This is due to the fact that the greatest part of the effort in drawing a load over a muddy road is consumed in squeezing the mud out from under the wheels in order to secure a solid bottom for the wheel to roll upon. The resistance which a load offers to being drawn is divided into (1) rolling resistance, which is that just above mentioned, and is due to the striking of the wheel in the surface of the road, causing the load to be continually drawn up an incline; (2) axle friction; (3) resistance of the air. These last two elements are but a very small part of the resistance to overcome on a muddy road, and the rolling resistance is nearly

all of it. It follows that the added draft in pulling a load up a slight incline in a muddy road is not so great in proportion to the draft on a level stretch as it is on a hard surfaced road. On a macadam surface the rolling resistance is decreased very decidedly and the other factors make up a proportionally larger amount.

"A road is only as good as its poorest part. If a team is able to haul three tons on the level part of the road and only one ton up a certain grade at the end, the load is limited to one ton. Consequently, as far as heavy hauling is concerned, the expense necessary to put the level part in shape so that more than three tons could be hauled is of no use until the hill is put in shape so that the three tons can be hauled over that also. It is poor economy, therefore, to build a level portion of a road in good shape without making the grade such that the load hauled on the level can be pulled up the hills with the extra effort which a team is capable of exerting for a short space of time." It is therefore evident that the maximum grade that should be permitted in the location of a road must depend upon the nature of the surface the road is to have.

A better appreciation of the resistance to hauling caused by grades can be gained from the following tables taken from Byrne's Highway Construction. The percentages vary slightly from those quoted from Baker's Roads and Pavements but cover a somewhat larger range.

"The first table shows a comparison of the amount that can be hauled over different grades and the amount which it is possible to haul under similar conditions over a level road. It is seen in case of an earth road that .41 as much can be hauled on a grade of 5 per cent. (5 feet per 100) as on a level earth road and but 10 per cent. as much on a grade of 15 feet per 100. Thus if a horse can pull 1,000 pounds on a level dirt road, on a 5-foot grade he can only pull 410 pounds and on a 15 per cent. grade but 100 pounds.

Table showing the relation between Load, Grade and Surface.

Grade.	Earth.	Broken Stones.	Stone Blocks.	Asphalt.
Level	1.00	1.00	1.00	1.00
1 : 100	.80	.66	.72	.41
2 : 100	.66	.50	.55	.25
3 : 100	.55	.40	.44	.18
4 : 100	.47	.33	.36	.13
5 : 100	.41	.29	.30	.10
10 : 100	.26	.16	.14	.04
15 : 100	.10	.05	.07	---
20 : 100	.04	---	.03	---

The second Table shows the equivalent length of level road over which the same amount of energy will be expended to haul a given load as would be required on one mile of road of different grades. Thus for example, the energy required to haul a given load one mile on a grade of one foot to the 100 feet is the same as is required to haul the same load over 1 1-2 miles of level road, the surface conditions being the same; while for a grade of 10 per cent. there is required to pull one mile on this grade energy equivalent to that spent in pulling over nearly six miles of level road.

Table showing relation between length of haul and grade.

Rate of grade ft. per 100 feet.	Equivalent length of level road miles.	Rate of grade per 100 feet.	Equivalent length of level road miles.
0.0	1.000	2.50	2.244
0.25	1.121	2.75	2.363
0.50	1.242	3.00	2.484
0.75	1.373	4.00	2.982
1.0	1.500	5.00	3.444
1.25	1.622	6	3.986
1.50	1.746	7	4.844
1.75	1.871	8	4.982
2	2.000	9	5.480
2.25	2.120	10	5.977

"If properly graded, it is no exaggeration to say that one-third of the roads now frequently rendered impassable from washouts would be nearly free from the effects of such accidents. The wear to a road-bed increases approximately as the sixth power of the velocity of the storm water flowing down it, and the velocity depends primarily upon the grade. It is useless to hope to maintain a road on a steep grade under ordinary circumstances. Every year special appropriations are made to meet such emergencies. "While it cannot be said that there would be no damage to a road from storm-water even if it were properly graded, it is a fact that the amount of damage in a particular instance would have been much greater if the grades had not been reduced."

The maximum grades established in different countries and states are of interest in this connection:

"In France the standard is; on national roads, not exceeding 3 per cent; department roads, not exceeding 4 per cent; and subordinate roads, not exceeding 6 per cent. On the great Alpine road over the Simplon Pass, built under the direction of Napoleon Bonaparte, the grades average 1 in 22 (4 1-2%) on the Italian side and 1 in 17 (5.9%) on the Swiss side, and in only one place become as steep as 1 in 13 (7.7%)."

In Great Britain, the celebrated Holyhead Road, built by Telford through the very mountainous district of North Wales, has an ordinary maximum of 1 in 30 (3 1-3%) with one piece of 1 in 22 (4 1-4%) and a few short pieces of 1 in 17, on both of which pieces special care was taken to make the surface harder and smoother than on the remainder of the road."

New York maximum grade is 5 or 6%.

New Jersey maximum grade is 6%.

Michigan maximum grade is 6%.

"It will readily appear that the proper location of many factors must be taken. When such a thing is contemplated the services of the most practical highway engineer obtainable should be secured without fail." Fortunately Alabama has recently authorized the organization of a Highway Commission

and the appointment of a State Highway Engineer has provided the means by which any community in the State can secure such expert service at very low cost.

RISE AND FALL.

Rise and fall is considered to be the rise in feet on an ascending grade and the corresponding feet of fall on some descending grade. One foot of rise and fall is a foot of ascent with its corresponding foot of descent. Rise and fall is measured by the number of vertical feet of rise, as shown by the differences of elevation on the profile. The introduction of rise and fall is a question between the increased cost of operation and the increased cost of construction required to fill up the hollow or cut down the hill, or between the cost of operation of the rise and fall and of the increased distance necessary to go around the obstruction. In discussing the effect of rise and fall upon the operation of a road a distinction must be made between three classes of rise and fall as follows: (See Baker on Roads) Class A. Rise and Fall on grades at a less slope than the angle of repose (the grade on which a vehicle by its own weight will maintain a uniform speed), and so situated as not to require any addition to the total power required to move a load over the road.

Class B. Rise and Fall on grades so steep as to require either the holding back of the load by the team or the application of brakes.

Class C. Rise and Fall on the maximum grades.

Take as an example of Class A Rise and Fall a road on which the grade changes from level to a descending grade of one per cent. for 400 feet in distance and then ascends by the same amount of per cent. grade until the same level is reached. The rise and fall in this case is 4 feet. The team is relieved on the down grade an amount exactly equal to the extra tax upon the up grade, and the only effect upon the team is that the effort is concentrated on the up grade instead of being uniformly distributed over the road, but as the slope is assumed to be equal to or less than the angle of repose,

the maximum effort is equal to or less than twice the normal. If the grade line rises above the level instead of dipping below it, the case is not changed except that the rise is a little more unfavorable, since the team has no relief before the increase in effort is required. Therefore this class of rise and fall costs little or nothing. A change of velocity would alter the power required at any particular instant.

"If the grade is greater than the angle of repose, the team in descending must hold back the load, which is lost energy, or brakes must be applied, which tend to destroy the road; and in ascending the demand upon the team is greater than twice the normal. Therefore in either case, this class of rise and fall adds to the cost of operation.

"If the grade is a maximum, it may be sufficient to limit the amount of the load a team may draw over the level portions of the road, and therefore greatly add to the cost of transportation."

Distance vs. Rise and Fall.

In locating a road the question may arise between the relative desirability of introducing rise and fall and of increasing the length of the line. The problem then is to determine the relative value of distance and of rise and fall. If Baker's conclusion is correct, that the cost of Class A. rise and fall is not appreciable, then the distance should not be increased at all to eliminate Class A rise and Fall.

"For Class B rise and fall an approximate solution can be obtained by assuming that it costs the same to develop a certain amount of energy in overcoming Class B rise and fall as to develop a like amount of energy in moving a load on a level road. This assumption is probably reasonably correct. For example, the tractive resistance of the best broken stone road is 33 pounds per ton, and the work necessary to raise 1 ton through 1 foot of rise is 2,000 foot-pounds; therefore to develop 2,000 foot-pounds of work on a level broken stone road, a ton must be moved 2,000 divided by 33 equal to 60 feet. Hence the cost of operating 60 feet of distance on this

road may be considered as equivalent to 1 foot of rise and fall of Class B. Therefore to eliminate a foot of rise and fall of Class B, the length of the road may be increased 60 feet."

The following table gives the corresponding distance for other road surfaces.

Table showing horizontal distance equivalent to 1 foot of Class B Rise and Fall.

Earth roads, muddy	Tractive resistance	200 lb. per ton	10 ft.
Earth roads, ordinary	Tractive resistance	100 lb. per ton	20 ft.
Earth roads, dry and hard	Tractive resistance	80 lb. per ton	25 ft.
Stone-block pavm't best	Tractive resistance	40 lb. per ton	50 ft.
Stone-block pavm't ordin'y	Tractive resistance	80 lb. per ton	25 ft.
Gravel, best	Tractive resistance	50 lb. per ton	40 ft.
Gravel, ordinary	Tractive resistance	80 lb. per ton	25 ft.
Broken stone road, best	Tractive resistance	33 lb. per ton	60 ft.
Broken stone road, ordin'y	Tractive resistance	50 lb. per ton	40 ft.
Sheet asphalt	Tractive resistance	20 lb. per ton	100 ft.

CURVES.

Theoretically the shortest radius of curvature allowable on roads depends upon the width of the road, and upon the maximum length of teams frequenting the road or upon the speed of the shorter teams. The length of a four-horse team and vehicle is about 50 feet and to permit such a team to keep upon a 12 foot roadway would require a radius of the inside of the curve of about 100 feet; on a 16-foot roadway a radius of about 75 feet would be required; and on a 18-foot roadway, a radius of about 66 feet. Wherever curves are necessary employ the greatest radius possible and never less than fifty feet. They may be circular or parabolic. When a curve occurs on an ascent, the grade at that point must be diminished to compensate for the additional resistance of the curve.

The width of the wheelway on curves must be increased. This increase should be one-quarter of the width for the central angles between 90 and 120 degrees, and one-half for angles between 60 and 90 degrees.

In France the minimum radius is as follows: On main and departmental roads of which the trackway is 20 to 22 feet wide, 165, and in extreme cases 100 feet; on principal country roads which are 20 feet wide, 50. In Saxony the minimum radius on principal roads is 82 feet, and on ordinary county roads it is 40 feet.

*Table showing approximately the increase in cost of hauling up different grades.

1% Grade or 1 foot in 100 feet	11%
2% Grade or 1 foot in 50 feet	23%
4½% Grade or 1 foot in 24 feet	100%
5% Grade or 1 foot in 20 feet	150%
10% Grade or 1 foot in 10 feet	400%

†Table showing approximate cost of hauling one ton per mile over different surfaces.

	cents.
Macadam dry and in good order	8
Sand-clay dry and in good order	8
Compact gravel road	13
Earth road dry and hard	18
Earth road ruts and mud	39

*From Bul. No. 8 So. Appalachian Good Roads Assoc. Also from Farm Bulletin No. 136 U. S. Dept. Agr.

†From Bul. No. 8 Appalachian Good Roads Assoc.

DRAINAGE OF EARTH ROADS.

By EDGAR B. KAY.

The drainage of roadways is of two kinds, viz: surface and subsurface. The first provides for the removal of all water falling on the surface of the roadway or which would naturally flow upon the roadway from contiguous property; the second provides for the removal of the underground waters found in the body of the ground, the thorough removal of which is of the utmost importance and essential to the life of the road surface. Drainage alone will often change a bad road to a good one, while the best stone road may be destroyed by the absence of proper drainage. "Water is the natural enemy of earth roads, for mixed with dirt it makes mud, and mud makes bad going. If water is allowed to course down the middle of the road, it will wash away the earth, and leave gullies in the surface that must be filled up by traffic or repairs. No road, however well made otherwise, can endure, if water collects or remains on it. Prompt and thorough drainage is a vital essential in all road construction especially for earth roads.

UNDERDRAINAGE.

A road-covering placed on a wet undrained bottom will be destroyed by both water and frost, and will always be troublesome and expensive to maintain. Perfect subsoil drainage is a necessity and will be found economical in the end even if it requires considerable expense to secure it.

The methods employed for securing the subsoil drainage must be varied according to the character of the natural soil, each kind of soil requiring different treatment. The natural soils may be divided into the following classes: silicious, argillaceous and calcareous; rock, swamps, and morasses.

The silicious and calcareous soils, the sandy loams and rock present no great difficulty in securing a dry and solid founda-

tion. Ordinarily they are not retentive of water and therefore require no underdrains; ditches on each side of the road will generally prove sufficient.

The argillaceous soils and softer marls require more care; they retain water and are difficult to compact, except at the surface; and they are very unstable under the action of water and frost.

Any soil in which the standing water in the ground comes at any season of the year within 4 or 5 feet of the surface will be benefited by drainage; that is, if the soil does not have a natural subdrainage, it will be improved for road purposes by artificial subsurface drainage. It is the universal observation that roads in low places which are underdrained dry out sooner than undrained roads on high land. Underdrained roads never get as bad as do those not so drained. "Underdrainage without grading is better than grading without drainage; and in general it may be said that there is no way in which road taxes can be spent to better advantage than in subsurface drainage." Underdrainage is the very best preparation for a gravel or stone road, since gravel or stone placed upon an undrained foundation is almost sure to sink, even if slowly, whatever its thickness; whereas a thinner layer upon a drained road bed will give much better service.

While there is a quite general opinion that the sole object of underdrainage is to remove surface water it is but a small part of the advantages of the underdrainage of roads. The most important object is to lower the water level in the soil. The action of the sunshine and breeze will finally dry the surface of the road; but if the foundation is soft and spongy, the wheels will wear ruts and the horses' feet will make depressions between the ruts. The first shower fills these depressions with water, and the road is soon a mass of mud. A second object of underdrainage is to dry the ground quickly after a freeze. Under ordinary conditions in Alabama the frost action is not of sufficient occurrence or severity to justify the serious attention of the engineer or road builder except in the northern half of the State. When the frost comes out of the ground, the thawing is quite as much from

the bottom as from the top. If the land is underdrained, the water when released by thawing from below will be immediately carried away. This is of the greatest importance in road drainage, since the foundation will then remain solid and the road itself will not be cut up. A third and sometimes a very important object of underdrainage is to remove what is known as the underflow. In some places where the ground is comparatively dry when it freezes in water it will be very wet when the frost comes out, similarly in certain fills in depressions the hydrostatic pressure of the water in higher contiguous lands rises slowly in the soil and if it is not drawn off by underdrainage it saturates the subsoil.

The Tile.

The best and cheapest method of securing underdrainage is to lay a line of porous or farm tile 3 or 4 feet deep on one or both sides of the roadway. The tiles are made from terra-cotta or burnt clay, are porous and are far superior to all other kinds of drains. They carry off the water with greater ease, rarely if ever get choked up and only require a slight inclination to keep the water moving through them. The ordinary farm tile is entirely satisfactory for road drainage. It should be uniformly burned, straight, round in cross-section, smooth inside, and have the ends cut off square. Tile may be had from 3 to 30 inches in diameter. The smaller sizes are usually a little over one foot long,—the excess length being designed to compensate for breakage. The larger sizes are nominally 2 or 2 1-2 feet long, sometimes a little longer. Where collars are used, pieces of the larger pipe serve as collars for the smaller sizes. The collar which encircles the joint of the small tile allows a large opening. and at the same time prevents sand and silt from entering the drain. Connections should be made by proper Y-branches. Recent practice requires only that the tiles shall be laid with their ends in contact, care being taken to turn them until the ends fit reasonably close. If the bottom of the trench is made but little wider than the diameter of the tile, or if a groove is scooped

out in the bottom of the trench to fit the tile, no difficulty need be apprehended from this source. The cost of tile free on board cars at factory is usually about as given in Table

Table showing cost and weight of drain tile.

Inside diameter	Price per 1,000 f. o. b. factory	Weight per foot	Number of feet in a car load.
3 inches	$ 10 00	5 lbs.	7,000
4 inches	15 00	7 lbs.	6,500
5 inches	20 00	9 lbs.	5,000
6 inches	27 00	12 lbs.	4,000
7 inches	35 00	14 lbs.	3,000
8 inches	45 00	18 lbs.	2,500
9 inches	55 00	21 lbs.	1,800
10 inches	65 00	25 lbs.	1,600
12 inches	90 00	33 lbs.	1,000
14 inches	120 00	43 lbs.	800
16 inches	150 00	50 lbs.	600
18 inches	240 00	70 lbs.	400
20 inches	300 00	83 lbs.	330
24 inches	360 00	112 lbs.	300

FALL OF DRAINS.

Ordinarily there is little danger of the grade of the tile drain being too great, and generally the problem is to secure sufficient fall. Many authorities on farm drainage and several engineering manuals assert that a fall of 2 1-2 or 3 inches per 100 feet is the lowest limit that should be attempted under the most favorable conditions; but practical experience in the northwest and western states has abundantly proved that a smaller fall will give good drainage. "In Illinois and Indiana are many lines of tile having falls of only 1-6 to 1-4 of an inch per 100 feet which are giving satisfactory drainage; and not unfrequently the ordinary porous tiles laid absolutely level directly upon the earth in the bottom of the trench, without collars or other covering over the joints, have given good drainage without trouble from the deposit of sediment."

"If possible at reasonable expense, the grade should be at least 2 inches per 100 feet; and should never be less than 1-2 inch per 100 feet unless absolutely necessary." It is frequently possible to secure added fall in the tile line by laying the tile at the upper end shallower than at the lower. This applies to level, or practically level ground.

SIZE OF TILE.

Baker gives the following formula to determine the size of tile:

$$Q = 39.25 \sqrt{\frac{f}{l} D^5} \quad \text{--------------------} \quad (1)$$

in which Q is the discharge in cubic feet per second, f the fall in a distance l (both in feet), and D the inside diameter of the tile in feet. The above formula may be reduced to the following more usual form:

$$V = 6798 \sqrt{\frac{f}{l} d^5} \quad \text{--------------------} \quad (2)$$

in which V is the discharge in cubic feet per 24 hours, and d is the diameter of the tile in inches. Water 1 inch deep over an acre of land amounts to 3,630 cubic feet; and therefore if we divide the constant in equation (2) by 3,630, we get the following formula:

$$A = 1.9 \sqrt{\frac{f}{l} d^5} \quad \text{--------------------} \quad (3)$$

in which A is the number of acres for which a tile having a diameter of d inches and a fall of f feet in a length of l feet will remove 1 inch in depth of water in 24 hours. The above formula will be found useful in localities where there is no local experience with tile; and the chief value consists in showing the relation between capacity and grade, and the effect of a variation in the diameter of the tile.

The best practice in agricultural drainage provides for the removal of 0.5 to 1 inch of water per day; but since the side ditches will assist in removing rain water from the road, it is probable that a provision for the removal of half an inch per day is sufficient for the underdrainage of a road. Where there

is likely to be underflow of water from higher ground or where the ground is "springy" the ordinary provisions for under-drainage should be increased.

In the New York 1905 Red Road Book appears the following: "Porous tile drains, or vitrified pipe, six inches in diameter and laid from three to four feet below the surface, make the best form of under-drain."

It is not wise to lay a smaller tile than a 4-inch one, and probably not smaller than a 5-inch. Tiles can'not be laid in exact line, and any tilting up of one end reduces the cross-section. Again, if there is a sag in the line equal to the inside diameter, the tile will shortly become entirely stopped by the deposit of silt in the depression. It is sometimes wiser to lay a larger tile than to increase the fall. Again it may be better to lay a large tile near the surface with smaller fall than to lay small tile deeper with a greater fall. Ordinarily, the deeper the tile the better the drainage, although 3 1-2 or 4 feet deep is usually sufficient.

Laying the Tile.

The individual tiles should be laid in line both vertically and horizontally, with as small joints at the end as practicable, Care should be taken that the tile is laid to a true grade, particularly if the fall is small, for a sag will cause silting up as previously pointed out and if there is a crest in the line silt will be deposited just above it up the grade. The drain should have a free and adequate outlet. The end of the tile line should be protected by concrete masonry, by plank nailed to posts or by replacing three or four tiles at the lower end by an iron pipe or a concrete or wooden box.

In the New York Bulletin No. 10 Department of the State Engineer appears the following:

"Wherever the grade is less than three inches per hundred feet or wherever the sub-soil is very unstable, there shall be laid in the bottom of the trench, as a foundation for the tiles boards one inch thick, three or four inches wide and 12 or more feet long, the ends being joined by nailing them to pieces

beneath them. Tile has sometimes proved to be very effective, when laid in this manner and nearly level; but in this case it is advisable to use larger diameter pipe at the outlet and gradually decrease the diameter as the distance from the outlet increases in order to increase the fall."

Tests made at the Illinois Agricultural Experiment Station indicate that one line of tile 2 1-2 to 3 feet deep under the ditch at one side of the road will give fairly good drainage under the most adverse conditions. The above experiment consisted in the drainage of a piece of land selected as the worst that could be found in a part of the state notorious as having a large area of hard-pan which it was generally considered could not be underdrained "because the soil held water like a jug." Lines of tile were laid 2 1-2 feet deep and 50 feet apart. The water level at a point midway between the lines was lowered 18 inches, when at the same time the water level in the undrained portion of the field was only 6 inches below the surface. In this case the surface of the ground water had a slope of 1 foot in 25 feet. Baker says that other observations confirm the above result for the slope of the surface of saturation. The exact form of the surface of saturation is not known, but it is known to be a curve slightly convex upward. The inclination varies with the nature of the soil. It is most convex near the tile, and is most convex immediately after a rain and gradually thereafter approaches an inclined plane.

For agricultural drainage it is conceded that it is sufficient to place lines of tile 100 feet apart, provided they are of reasonable size and at sufficient depth. A tile will give agricultural drainage 50 feet on either side of it; that is a tile under only one side ditch will give agricultural drainage for the traveled way, since the traveled way is usually not more than 50 feet wide and on most Alabama roads much narrower. More thorough drainage is required for road purposes, because "when damp, most soils will pack, which is harmful to agricultural land and beneficial to the road." In some localities a stratum of hard pan near the surface makes it necessary to lay the tile so shallow that two lines are really required; and sometimes the tile is so small or poorly laid that one line

is not sufficient. "In case of doubt as to whether one or two lines of tile are needed put in one and watch results. If both sides of the road are equally good, another tile drain is not needed." "In making these observations care should be taken not to overlook any of the factors, as for example, the difference in the effect of the sun upon the north and the south sides of the road, the effect of shade or of seepage water, the transverse slopes of the surface of the road, etc."

"With the same depth of digging, a tile under the side ditch is more effective than one under the center of the road. Further, if the tile is under the center, there is liability of the settling of the soil in the trench, which will make a depression and probably a mud hole; and if the tile becomes stopped, it is expensive to dig it up, and the doing so interferes with traffic. Finally, if the road is ever graveled or macadamized, the disadvantage of having the tile drain under the center of the road is materially increased."

Surface Drainage.

Closely associated with the establishment of the grade of a road is that of the drainage. The Road Laws of Alabama vary in the powers given to County Road Commissioners and attention is here called to the necessity of adequate regulations in the Code in the development of the system of state highways recently inaugurated by legislative authority. Definite laws are needed to permit the drainage of water from the roads onto adjacent property; taking care that cultivated lands are not injured; to regulate the drainage of the run-off from road bed into private lands and to regulate those problems resulting from the inflow upon roadways of contiguous lands.

The storm water is frequently kept in the road-bed until some water course is crossed. The amount of water actually falling upon the roadway is often less than the amount that is collected from the neighboring slopes. Where provision is made for intercepting the water from the sides by ditches made part of the way up the slope there is less danger of the roadway itself being seriously damaged by the storm water.

No embankment of any sort should be allowed which keeps the storm water in the road-way. Wherever it is necessary to dig a ditch through adjacent lands in order to dispose of the road drainage, it may be just that damages be allowed the landowner. As a rule, however, the actual damage can be practically nothing, or at most very little, provided a little judgment is exercised in placing these lateral drains. The more frequent the outlets from the road of the storm water the less the volume which it is necessary to carry in the gutters and side ditches, and consequently, the less the amount of water and destruction of the road-bed.

The drainage of the surface of a road is of the greatest importance and is provided for by making the surface crowning and in keeping it smooth. Water upon the surface of the road can not be carried away by the underdrains, since the water can reach them only after it has penetrated and softened the road surface. The slope from the center to the side should be enough to carry the water freely and quickly to the side ditch; and if the surface is kept free from ruts and holes, less crown will suffice than if no attention is given to keeping the surface smooth. The crown should not be so great that vehicles are compelled to keep in the center, as in that case the road will be worn hollow and surface water will be retained. In extreme cases of too much crowning, it is sometimes difficult for vehicles to turn out in passing. Provided the road is properly maintained and the surface kept smooth, a crown of one inch to one foot is ample. More crown is required on very steep grades, as the water in flowing from the center of the road to the sides travels diagonally and not at right angles to the center line as in the case of level road.

If the surface is too flat the water will follow down the center, the wheel-tracks will become deepened, stones become loosened, and the road surface made rough and dangerous.

The drainage of the surface of a road is chiefly a matter of maintenance and one of the most common defects of maintenance is the failure to fill the ruts and keep the surface smooth so that the water will be promptly discharged into the side ditches. A comparatively shallow rut will nullify the effect of

any reasonable amount of crown, and wear deeper and deeper with each passing vehicle.

CROSS-DRAINAGE.

"Catch-waters," "water-breaks," "hummocks" or "thank-you-marms" to turn the surface drainage into the side ditches should not be constructed on improved roads. They increase the grade and are an impediment to convenient and easy travel. Where it is necessary that water should cross the road a culvert should be built.

Whatever the form of the road surface, if the hillside is steep there should be a "catch-water" above the road to prevent the water from the hillside above from flowing down on the road. It should be at least 6 feet back from the top of the side slope or excavation and should have a width and depth according to the amount of water to be intercepted.

CULVERTS.

Culverts are necessary for carrying under a road the streams it crosses, and also for conveying the surface water collected in the side ditches from the upper side to that side on which the natural water courses lie.

Especial care is required to provide an ample way for the water to be passed. If the culvert is too small, it is liable to cause a washout, entailing interruption of traffic and cost of repairs, and possibly may cause accidents that will require the payment of large sums for damages. It is the province of the engineer to design a culvert of sufficient but not extravagant size.

The area of water-way required depends (1) upon the rate of rainfall; (2) the kind and condition of the soil; (3) the character and inclination of the surface; (4) the condition and inclination of the bed of the stream; (5) the shape of the area to be drained, and the position of the branches of the stream; (6) the form of the mouth and the inclination of the bed of the culvert; and (7) whether it is permissible to back the

water up above the culvert, thereby causing it to discharge under head.

(1) It is the maximum rate of rainfall during the severest storms which is required in this connection. The Government records show a rate of rainfall per hour for a period of five minutes of 9 inches at Bismark, N. D.; a rate of 6.60 inches per hour for a period of ten minutes at Jacksonville, Fla.; and of 2.55 inches per hour for a period of an hour at Galveston, Texas. Since one inch of rainfall per acre equal 3,630 cubic feet, the Galveston record of 2.55 inches represents 9256.5 cubic feet per acre per hour. Owing to various causes, not more than 50 to 75 per cent. of this amount will reach the culvert within the same hour. The maxium run-off of any American stream of which there is record is about 157 second feet per square mile of drainage area.

(2) The amount of water to be drained off will depend upon the permeability of the surface of the ground, which will vary greatly with the kind of soil, the degree of saturation, the condition of the cultivation, the amount of vegetation, etc.

(3) The rapidity with which the water will reach the watercourse depends upon whether the surface is rough or smooth, deep or flat, barren or covered with vegetation, etc.

(4) The rapidity with which the water will reach the culvert depends upon whether there is a well-defined and unobstructed channel, or whether the water finds its way in a broad thin sheet. If the water course is unobstructed and has a considerable inclination the water may arrive at the culvert nearly as rapidly as it falls; but if the channel is obstructed, the water may be much longer in passing the culvert than in falling.

(5) The area of the water-way depends upon the amount of the area to be drained; but in many cases the shape of this area and the position of the branches of the stream are of more importance than the amount of territory. If the area is long and narrow, the water from the lower portion may pass through the culvert before that from the upper end arrives; or, on the other hand, if the upper end of the area is steeper

than the lower, the water from the former may arrive simultaneously with that from the latter. If the lower part of the area is better supplied with branches than the upper the water from the lower portion may be carried beyond the culvert before the arrival of water from the upper portion, on the other hand if the upper portion is better supplied with well defined water-courses, the water from the whole area may reach the culvert at nearly the same time. In large areas the shape of the catchment and the position of the water-courses are very important considerations.

(6) The efficiency of the culvert may be materially increased by so arranging the upper end that the water may enter it without being retarded. The discharging capacity of a culvert can also be increased by increasing the inclination of its bed, provided the channel below will allow the water to flow away freely after passing the culvert.

(7) The discharging capacity of a culvert can be greatly increased by allowing the water to dam up above it. A culvert will discharge twice as much under a head of four feet as under a head of one foot. The practice of designing culverts to discharge under head is not recommended. Many culverts of ample area fail to carry off the water properly, because of floating material, such as brush, trees, etc., which are allowed to obstruct the channel and choke up the culvert.

The determination of the values of the above different factors entering into the problem is largely a matter of experience and judgment. An estimate of any one of the factors is liable to be in error 100 per cent. or more. Mathematical exactness is ordinarily not required by the problem nor warranted by the data. The question is not one of 10 or 20 per cent. increase; for if a 2-foot pipe is insufficient, a 3-foot pipe will probably be the next size, an increase of 225 per cent; and if a 6-foot arch culvert is too small, an 8-foot will be used, an increase of 180 per cent. The real question is whether a 2-foot pipe or an 8-foot arch culvert is needed.

Valuable data on the proper size of any particular culvert may be obtained (1) by observing the existing openings on the same stream; (2) by measuring, if practicable at time of

high water, a cross-section of the stream at some narrow place and the determination of the velocity of the current; (3) by determining the height of high water as indicated by drift.

Numerous empirical formulas have been proposed for the determination of the required waterway area. A purely theoretical solution is impracticable, but all of the above conditions should be considered in estimating the value of the constant to be used in a particular case in applying any empirical formula of which some are quoted below. Let a=area of waterway in square feet and A=drainage area in acres. Then by

E. T. D. Myer's formula $a = C\sqrt{A}$ in which C is a coefficient varying from 1 for flat country to 4 for mountainous country and rocky ground.

A. N. Talbot's formula, $a = C\sqrt[4]{A^3}$ For steep and rocky ground C varies from 2-3 to 1. For rolling agricultural country, subject to floods at times of melting snow, and with the length of the valley three or four times its width, C is about 2-3; and if the stream is longer in proportion to its area, decrease C. In districts not affected by accumulated snow, and where the length of the valley is several times the width, 1-5 or 1-6 or less may be used. C should be increased for steep side slopes, especially if the upper part of the valley has a much greater fall than the channel at the culvert.

J. I. Fanning's formula, $a = 0.23\sqrt[6]{A^5}$ in which no allowance is made for variations in conditions which affect the flow.

C. B. & Q. formula, $a = 0.46875\,A/\,(3 + 0.079\sqrt{A})$.

Side Ditches.

The side ditches are to receive the water from the surface of the traveled way, and should carry it rapidly and entirely away from the roadside. They are useful, also, to intercept and carry off water that would otherwise flow from the side

hills upon the road. Ordinarily they need not be deep; but, if possible, should have a broad, flaring side toward the traveled way, to prevent accident if a vehicle should be crowded to the extreme side of the roadway. The outside bank should be flat enough to prevent caving.

If the road is tiled as hereinbefore recommended, the side ditch need not be very large; but it should be of such form as to permit its construction with the road machine or scraping grader or in part with the drag scraper, instead of requiring it to be made by hand. On comparatively level ground, the proper form of side ditch is readily and cheaply made with the usual road machine. If a larger ditch is needed, it should be of such a form as to be made chiefly with the drag-scoop scraper. A deep narrow ditch is expensive to maintain, since it is easily obstructed by the caving banks, by weeds and by floating trash. The shallow ditch is easy and cheap to construct and also to maintain.

If it is necessary to carry water along the side of the road through a rise in the ground, it is much better to lay a line of tile and nearly fill the ditch than to attempt to maintain a narrow deep ditch. A tile is much more effective per unit of cross section than most open ditches.

The side ditch should have a uniform grade and a free outlet into some stream or water course, so as to carry the water entirely away from the road. No good can be obtained with side ditches that hold the water until it evaporates.

When the road is in excavation, great care should be taken that a ditch is provided on each side to carry away the water so that it shall not run down the middle of the road. Every road should have side ditches, even one that runs straight down the side of the hill. The steepest road needs the side ditch most, although it often has none.

If it can be prevented, no attempt should be made to carry water long distances in side ditches; for large bodies of water are hard to handle, and are liable to become very destructive. Side ditches should discharge frequently into the natural watercourses, though to compass this, it may be necessary in some cases to carry the water from the high side to the low side of the road.

THE USE OF WIDE TIRES.

By Wm. F. Prouty.

Numerous tests made under all kinds and conditions of roads show that the draft of a wagon with wide tires is, with very few exceptions, less than that of a wagon and narrow tires. The real advantage of the wide tire is not, however, so much due to the less draft as to a much more important fact. Wherever the wide tires are used on a road instead of the narrow tires there is always an improvement in the character of the road. The surface becomes much more even and harder, the deep ruts are filled and the drainage in consequence improved. The reason for this betterment is evident. It is merely that the weight of the load is distributed over a much larger area of tire and in consequence there is a much less cutting and grinding force, with an attendant less rutting and powdering of the road material.

The wide tire is most effective on heavy wagons and in the country districts where the roads are both narrow and made of soft materials. Here there is a tendency for the wheels to run in the same narrow tracks and consequently for ruts to be formed.

The beneficial effects of the wide tire are not, however, confined to the country districts and the dirt road. On the macadam road, where the surface is hard, the narrow tire naturally has less cutting effect than on sand and clay. Its deleterious effects are, however, readily seen. Many stones are loosened and thrown out of place while only a small percentage of those already on the surface are imbedded again by the narrow tired wheels. The greater pressure of the narrow tires increases the amount of rock which is ground to a powder and in consequence the destruction of the road is hastened.

The action of the broad tire on the macadam road is most evidenced by the absence of coarse pieces of rock from the surface, these having been imbedded by the rolling effect of the wider tires.

On narrow roads where the running surface is restricted, a doubly beneficial effect may be obtained by using a different length axle for the front and rear wheels in connection with broad tires. I have observed the use of such on a limestone macadam road leading from the Onondaga Indian Reservation, Onondaga County, N. Y., and in other places with uniform highly satisfactory results. The difference in the length of axle should be slightly less than twice the width of the tire thus allowing for a little overlap.

I wish to quote here the statement of one of the Highway Commissioners of the State of Maine in regard to the use of wide tires in his State.

> "The heavy teaming in our town is confined mainly to the three miles of dirt road over which lime rock is hauled from the quarries to the kilns. This teaming has been done for years on 2 1-2 inch tires. The resulting repairs made necessary by the continual hauling of heavy loads on narrow tires have cost this town thousands of dollars. In order that this might be remedied we made an agreement with the lime rock haulers to furnish them with the wide tired wheels fitted to their wagon axles with the understanding that if upon fair trial the experiment should prove to be of mutual advantage the haulers should buy them of the town.
>
> Four sets of wheels with six wide tires were purchased by the board of select men. A set of these wide tires was put on one of the dray wagons and rock was hauled for the draymen for one day as an experiment.
>
> Our teamster hauled the same loads and followed in the old tracks. The road was in a very dangerous condition at this time and badly rutted, so that even light driving wagons sank to their hubs in some places. The wide tires soon filled the ruts so that the wagons with the narrow tires actually hauled more rock on the last or fourth turn that day than they did in the morning.
>
> After seeing the work of these wheels for one day, the owner of the wagon wanted the whole equipment immediately and applications for the other three sets came in

> so fast that we were unable to shift the gearing fast enough. In fact one teamster drove his team for a week without brakes in order to have the wheels sooner. Since that time the wheels have been in constant use summer and winter.
>
> At the time this is being written the same amount of rock per day is being hauled in three turns that was formerly hauled in four turns by the same teams, and the drivers claim the work is being done easier by the horses. The sand stretch which was the hardest place with the narrow tires is now crossed easily.
>
> Our expenditures for repairs upon this road since the use of wide tires have become general and have amounted to almost nothing. By their use the ruts are filled up and the road-bed is kept smooth and consequently dry."

A number of states have taken up the matter of wide tire legislation and some are compelling their citizens to use wide tires on heavily loaded wagons.

The introduction of wide tires may be brought about in several ways. Chief among these methods the following are probably the most feasible: by prohibiting the manufacture of narrow tired wagons for heavy loads; by placing a prohibitive tax on narrow tires; by limiting the amount of load that may be hauled by the width of the tire. Of these methods the last has probably been adopted more generally than any other.

In the state of Ohio the following is considered the logical arrangement of burdens for varying width of tires where there is a 3,400 pound limit for tires of less than three inches in width:

Vehicles with 1 inch tires	900 pounds.
Vehicles with 1 1-2 inch tires	1200 pounds.
Vehicles with 1 3-4 inch tires	1600 pounds.
Vehicles with 2 inch tires	2000 pounds.
Vehicles with 2 1-4 inch tires	2400 pounds.
Vehicles with 2 1-2 inch tires	2900 pounds.
Vehicles with 2 3-4 inch tires	3400 pounds.
Vehicles with 3 inch tires	4300 pounds.
Vehicles with 3 1-2 inch tires	5300 pounds.

Vehicles with 4 inch tires............6500 pounds.
Vehicles with 4 1-2 inch tires........7900 pounds.
Vehicles with 5 inch tires............9500 pounds.
Vehicles with 6 inch tires..........11500 pounds.

In Ohio also various counties have adopted laws governing the use of wide tires differing more or less in their requirements of width of tire for a given load.

In Van Wert Co. for example the following regulations have been made. "It is unlawful to haul during late fall, winter and spring, except when roads are dry and frozen, a burden of

3400 pounds on less than 3 inch tire.
3500 pounds on less than 4 inch tire.
3600 pounds on less than 6 inch tire.
4000 pounds on less than 8 inch tire.
8 inch or more may carry 6000 pounds.

These weights are inclusive of vehicles. Trustees, road superintendents and road commissioners are to enforce the law."

In practically all cases the counties in Ohio have passed laws requiring wider tires, for the heavier loads, than is shown in the table of logically arranged burdens.

It would seem that such law should be operative especially during all times when the road is in a condition to be rutted easily.

In all places where the wide tire laws have been in operation there has been marked improvement in the character of the roads. In many places where rough roads have been gone over in the drier season by many wide tired wagons, especially if the front and back axles are of different length, the roads have been wonderfully improved. Under the same conditions with narrow tired wagons, there would have been developed ruts of considerable depth.

APPENDIX

*LIST OF BOOKS BEARING ON ROAD AND STREET CONSTRUCTION.

	Name.	*Author.*	*Price.*
a	American Highways	Shaler	$1.50
	Asphalts	Boorman	3.00
	Catalogue of Minerals	Prof. Chester	1.25
b	Cements, Limes and Plasters	Eckel	6.00
c	Cements, Mortars and Concretes	Falk	3.50
d	City Roads and Pavements	Judson	2.00
b	Civil Engineer's Pocket Book	Trautwine	5.00
e	Clays: Their Occurrence, Prepertles and Uses	Ries	5.00
c	Concrete Bridges and Culverts	Tyrrell	3.00
	Concrete in Highway Construction	Atlas Cement Co.	1.00
b	Concrete, Plain and Reinforced	Trautwine, Jr.	2.00
c	Cost Data	Gillette	5.00
d	Design of Highway Bridges	Ketchum	4.00
d	Economics of Road Construction	Gillette	1.00
f	Engineering Works in Towns and Small Cities	McCullough	3.00
g	General Specifications for Concrete Bridges (2nd Ed.)	Watson	1.00
b	Highway Construction	Byrne	5.00
	Highway Engineering	Morrison	2.50
b	Hydraulic Cement	Spalding	2.00
b	Inspection of the Materials and Workmanship employed in Construction	Byrne	3.00
h	Law of Contracts	Wait	3.00
	Materials of Construction	Johnson	6.00
b	Modern Asphalt Pavement	Richardson	3.00
b	Modern Methods of Street Cleaning	Soper	3.00
e	Municipal Franchises (Vol. I)	Wilcox	5.00
	Municipal Improvements	Goodhue	1.50
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d	The Art of Roadmaking	Harwood Frost	3.00
	Report of the Association for Standardizing Paving Specifications, address John B. Hittell, Sec.-Treas., 5917 Winthrop Ave., Chicago		5.00
e	Highways and Byways of the South	Clifton Johnson	2.00

a Century Co., New York.
b John Wiley & Son, New York.
c Myron Clarke, Chicago.
d Engine'g News Pub. Co., N. Y.
e Macmillan Co., N. Y.
f Technical Book Agency, Chicago.
g J. B. Savage Co., Cleveland, O.
h Bender, Albany, N. Y.
i Van Nostrand, N. Y.
j D. Fourdrenier, London, Eng.

*These books may also be purchased through the Good Roads Pub. Co., 150 Nassau Street, N. Y.

OTHER REFERENCES TO ROAD LITERATURE.

1. The Reports of the Highway Commissioners of various states.
2. Circulars and pamphlets by the U. S. Office of Public Roads Dept. of Agr., distributed free upon request.
3. Good Roads Magazine, 150 Nasasu Street, N. Y., $1.00 per year.
4. Reports of State, National and International Good Roads Association and Reports of special committees appointed to investigate road matters.
5. Articles and current news in a number of magazines and journals such as The Manufacturers Record, The Tradesman, The Engineering News, etc.

*TABLE SHOWING NUMBER OF TONS OF STONE PER MILE REQUIRED TO BUILD THE FOLLOWING DEPTHS AND WIDTHS.

For the information of intending road builders, we have compiled the following tables, which approximate the number of tons of thoroughly rolled stone necessary to construct each mile at the designated depths and widths.

The basis is 3,000 tons of loose stone or 3,500 tons of compressed stone for a road one mile long, sixteen feet wide and eight inches deep. A road eight inches deep, when finished, will have required at least ten inches of stone. It should be placed in two layers of five inches each, and each layer rolled down to four inches. Then the application of the three-quarter inch and screenings will bring the road to the prescribed depth; for other thickness the stone should be placed in proportion to the intended finished depths.

An observance of this rule will insure the contract thickness for the roadbed, and save the sometimes necessary expense of resurfacing before acceptance from the contractor.

A road	8	feet	wide and	4	inches deep	will require	875	tons of	stone	per mile
"	8	"	"	6	"	"	1,312½	"	"	"
"	8	"	"	8	"	"	1,750	"	"	"
"	8	"	"	10	"	"	2,187½	"	"	"
"	8	"	"	12	"	"	2,625	"	"	"
"	9	"	"	4	"	"	984⅜	"	"	"
"	9	"	"	6	"	"	1,476 9/16	"	"	"
"	9	"	"	8	"	"	1,968¾	"	"	"
"	9	"	"	10	"	"	2,460 15/16	"	"	"
"	9	"	"	12	"	"	2,953⅛	"	"	"
"	10	"	"	4	"	"	1,093¾	"	"	"
"	10	"	"	6	"	"	1,640⅝	"	"	"
"	10	"	"	8	"	"	2,187½	"	"	"
"	10	"	"	10	"	"	2,734⅜	"	"	"
"	10	"	"	12	"	"	3,281¼	"	"	"

*From report of Commissioner of Public Roads, N. J.

A road	11	feet wide and	4	inches deep	will require	1,203⅛	tons	of stone	per mile
"	11	" "	6	"	"	1,804 11/16	"	"	"
"	11	" "	8	"	"	2,406¼	"	"	"
"	11	" "	10	"	"	3,007 13/16	"	"	"
"	11	" "	12	"	"	3,609⅜	"	"	"
"	12	" "	4	"	"	1,312½	"	"	"
"	12	" "	6	"	"	1,968¾	"	"	"
"	12	" "	8	"	"	2,625	"	"	"
"	12	" "	10	"	"	3,281¼	"	"	"
"	12	" "	12	"	"	3,937½	"	"	"
"	13	" "	4	"	"	1,421⅞	"	"	"
"	13	" "	6	"	"	2,132 13/16	"	"	"
"	13	" "	8	"	"	2,843¾	"	"	"
"	13	" "	10	"	"	3,554 11/16	"	"	"
"	13	" "	12	"	"	4,265⅝	"	"	"
"	14	" "	4	"	"	1,531¼	"	"	"
"	14	" "	6	"	"	2,296⅞	"	"	"
"	14	" "	8	"	"	3,062½	"	"	"
"	14	" "	10	"	"	3,828⅛	"	"	"
"	14	" "	12	"	"	4,593¾	"	"	"
"	15	" "	4	"	"	1,640⅝	"	"	"
"	15	" "	6	"	"	2,460 15/16	"	"	"
"	15	" "	8	"	"	3,281¼	"	"	"
"	15	" "	10	"	"	4,101 9/16	"	"	"
"	15	" "	12	"	"	4,921⅞	"	"	"
"	16	" "	4	"	"	1,750	"	"	"
"	16	" "	6	"	"	2,625	"	"	"
"	16	" "	8	"	"	3,500	"	"	"
"	16	" "	10	"	"	4,375	"	"	"
"	16	" "	12	"	"	5,250	"	"	"
"	17	" "	4	"	"	1,859⅜	"	"	"
"	17	" "	6	"	"	2,789 1/16	"	"	"
"	17	" "	8	"	"	3,718¾	"	"	"
"	17	" "	10	"	"	4,648 7/16	"	"	"
"	17	" "	12	"	"	5,578⅛	"	"	"
"	18	" "	4	"	"	1,968¾	"	"	"
"	18	" "	6	"	"	2,953⅛	"	"	"
"	18	" "	8	"	"	3,937½	"	"	"
"	18	" "	10	"	"	4,921⅞	"	"	"
"	18	" "	12	"	"	5,906¼	"	"	"
"	19	" "	4	"	"	2,078⅛	"	"	"
"	19	" "	6	"	"	3,117 3/16	"	"	"
"	19	" "	8	"	"	4,156¼	"	"	"
"	19	" "	10	"	"	5,195 5/16	"	"	"
"	19	" "	12	"	"	6,234⅜	"	"	"

A road	20	feet wide	and	4	inches deep	will require	2,187½	tons	of stone	per mile.
"	20	"	"	6	"	"	3,281¼	"	"	"
"	20	"	"	8	"	"	4,375	"	"	"
"	20	"	"	10	"	"	5,468¾	"	"	"
"	20	"	"	12	"	"	6,562½	"	"	"

TABLES.

As many persons interested in the construction of stone roads are asking questions about their cost, we enclose a table to show at a glance the number of square yards at different widths in a mile of road; also the cost at different widths, and various prices per square yard. Any variations from these prices can be quickly ascertained by adding, substracting, multiplying and dividing for a less or greater width. For example, a road eight feet wide has 4,693 1-3 square yards in one mile. To obtain the number of square yards in a road having a width of nine feet, add one-eighth to the foregoing figures, and in one having a width of seven feet, subtract one-eighth; in one of twice the width given in the table, multiply by two.

SQUARE YARDS IN ONE MILE OF

8	feet in width	4,693 1/3	square yards.
10	"	5,866 2/3	"
12	"	7,040	"
14	"	8,213 1/3	"
16	"	9,386 2/3	"
18	"	10,560	"

8	feet wide, or	4,693 1/3	square yards, at	25c.	per yard	$1,173	33 1/3
10	"	5,866 2/3	"	25c.	"	1,466	66 2/3
12	"	7,040	"	25c.	"	1,760	00
14	"	8,213 1/3	"	25c.	"	2,053	33 1/3
16	"	9,386 2/3	"	25c.	"	2,346	66 2/3
18	"	10,560	"	25c.	"	2,640	00
8	"	4,693 1/3	"	30c.	"	1,408	00
10	"	5,866 2/3	"	30c.	"	1,760	00
12	"	7,040	"	30c.	"	2,112	00
14	"	8,213 1/3	"	30c.	"	2,464	00
16	"	9,386 2/3	"	30c.	"	2,816	00
18	"	10,560	"	30c.	"	3,168	00

8	feet wide, or	4,693 $^{1}/_{3}$	square yards, at	35c.	per yard......	$1,642	66 $^{2}/_{3}$
10	"	5,866 $^{2}/_{3}$	"	35c.	"	2,053	33 $^{1}/_{3}$
12	"	7,040	"	35c.	"	2,464	00
14	"	8,213 $^{1}/_{3}$	"	35c.	"	2,874	66 $^{2}/_{3}$
16	"	9,386 $^{2}/_{3}$	"	35c.	"	3,285	33 $^{1}/_{3}$
18	"	10,560	"	35c.	"	3,696	00
8	"	4,693 $^{1}/_{3}$	"	40c.	"	1,877	33 $^{1}/_{3}$
10	"	5,866 $^{2}/_{3}$	"	40c.	"	2,346	66 $^{2}/_{3}$
12	"	7,040	"	40c.	"	2,816	00
14	"	8,213 $^{1}/_{3}$	"	40c.	"	3,285	33 $^{1}/_{3}$
16	"	9,386 $^{2}/_{3}$	"	40c.	"	3,754	66 $^{2}/_{3}$
18	"	10,560	"	40c.	"	4,224	00
8	"	4,693 $^{1}/_{3}$	"	45c.	"	2,112	00
10	"	5,866 $^{2}/_{3}$	"	45c.	"	2,640	00
12	"	7,040	"	45c.	"	3,168	00
14	"	8,213 $^{1}/_{3}$	"	45c.	"	3,696	00
16	"	9,386 $^{2}/_{3}$	"	45c.	"	4,224	00
18	"	10,560	"	45c.	"	4,752	00
8	"	4,693 $^{1}/_{3}$	"	50c.	"	2,346	66 $^{2}/_{3}$
10	"	5,866 $^{2}/_{3}$	"	50c.	"	2,933	33 $^{1}/_{3}$
12	"	7,040	"	50c.	"	3,520	00
14	"	8,213 $^{1}/_{3}$	"	50c.	"	4,106	66 $^{2}/_{3}$
16	"	9,386 $^{2}/_{3}$	"	50c.	"	4,693	33 $^{1}/_{3}$
18	"	10,560	"	50c.	"	5,280	00
8	"	4,693 $^{1}/_{3}$	"	55c.	"	2,581	33 $^{1}/_{3}$
10	"	5,866 $^{2}/_{3}$	"	55c.	"	3,226	66 $^{2}/_{3}$
12	"	7,040	"	55c.	"	3,872	00
14	"	8,213 $^{1}/_{3}$	"	55c.	"	4,517	33 $^{1}/_{3}$
16	"	9,386 $^{2}/_{3}$	"	55c.	"	5,162	66 $^{2}/_{3}$
18	"	10,560	"	55c.	"	5,808	00
8	"	4,693 $^{1}/_{3}$	"	60c.	"	2,816	00
10	"	5,866 $^{2}/_{3}$	"	60c.	"	3,520	00
12	"	7,040	"	60c.	"	4,224	00
14	"	8,213 $^{1}/_{3}$	"	60c.	"	4,928	00
16	"	9,386 $^{2}/_{3}$	"	60c.	"	5,632	00
18	"	10,560	"	60c.	"	6,336	00
8	"	4,693 $^{1}/_{3}$	"	65c.	"	3,050	66 $^{2}/_{3}$
10	"	5,866 $^{2}/_{3}$	"	65c.	"	3,813	33 $^{1}/_{3}$
12	"	7,040	"	65c.	"	4,576	00
14	"	8,213 $^{1}/_{3}$	"	65c.	"	5,338	66 $^{2}/_{3}$
16	"	9,386 $^{2}/_{3}$	"	65c.	"	6,101	33 $^{1}/_{3}$
18	"	10,560	"	65c.	"	6,864	00

8	feet wide, or	4,693 1/3	square yards, at	70c.	per yard........	$3,285 33 1/3
10	"	5,866 2/3	"	70c.	"	4,106 66 2/3
12	"	7,040	"	70c.	"	4,928 00
14	"	8,213 1/3	"	70c.	"	5,749 33 1/3
16	"	9,386 2/3	"	70c.	"	6,570 66 2/3
18	"	10,560	"	70c.	"	7,392 00
8	"	4,693 1/3	"	75c.	"	3,520 00
10	"	5,866 2/3	"	75c.	"	4,400 00
12	"	7,040	"	75c.	"	5,280 00
14	"	8,213 1/3	"	75c.	"	6,160 00
16	"	9,386 2/3	"	75c.	"	7,040 00
18	"	10,560	"	75c.	"	7,920 00
8	"	4,693 1/3	"	80c.	"	3,754 66 2/3
10	"	5,866 2/3	"	80c.	"	4,693 33 1/3
12	"	7,040	"	80c.	"	5,632 00
14	"	8,213 1/3	"	80c.	"	6,570 66 2/3
16	"	9,386 2/3	"	80c.	"	7,509 33 1/3
18	"	10,560	"	80c.	"	8,448 00
8	"	4,693 1/3	"	85c	"	3,989 33 1/3
10	"	5,866 2/3	"	85c.	"	4,986 66 2/3
12	"	7,040	"	85c.	"	5,984 00
14	"	8,213 1/3	"	85c.	"	6,981 33 1/3
16	"	9,386 2/3	"	85c.	"	7,978 66 2/3
18	"	10,560	"	85c.	"	8,976 00
8	"	4,693 1/3	"	90c.	"	4,224 00
10	"	5,866 2/3	"	90c.	"	5,280 00
12	"	7,040	"	90c.	"	6,336 00
14	"	8,213 1/3	"	90c.	"	7,392 00
16	"	9,386 2/3	"	90c.	"	8,448 00
18	"	10,560	"	90c.	"	9,504 00
8	"	4,693 1/3	"	95c.	"	4,458 66 2/3
10	"	5,866 2/3	"	95c.	"	5,573 33 1/3
12	"	7,040	"	95c.	"	6,688 00
14	"	8,213 1/3	"	95c.	"	7,802 66 2/3
16	"	9,386 2/3	"	95c.	"	8,917 33 1/3
18	"	10,560	"	95c.	"	10,032 00
8	"	4,693 1/3	"	$1.00	"	4,693 33 1/3
10	"	5,866 2/3	"	1.00	"	5,866 66 2/3
12	"	7,040	"	1.00	"	7,040 00
14	"	8,213 1/3	"	1.00	"	8,213 33 1/3
16	"	9,386 2/3	"	1.00	"	9,386 66 2/3
18	"	10,560	"	1.00	"	10,560 00

*TABLE FOR GRAVEL.

Table showing number of cubic yards of gravel required in the construction of one mile of gravel road, of widths varying from 6 feet to 20 feet, and depths from 6 to 12 inches. The within quantities should be multiplied by 1½ to give the number of cubic yards of loose gravel required to make the within depths of compact gravel.

One Mile in Length	Number of feet in width.	Number of cubic yards in road 6 inches deep.	Number of cubic yards in road 7 inches deep.	Number of cubic yards in road 8 inches deep.	Number of cubic yards in road 9 inches deep.	Number of cubic yards in road 10 inches deep.	Number of cubic yards in road 11 inches deep.	Number of cubic yards in road 12 inches deep
One mile	6 feet wide	586 2/3	684 4/9	782 2/9	880	977 7/9	1,075 5/9	1,173 1/3
One mile	7 feet wide	684 4/9	798 14/27	912 16/27	1,026 2/3	1,140 20/27	1,254 22/27	1,368 8/9
One mile	8 feet wide	782 2/9	912 16/27	1,042 26/27	1,173 1/3	1,303 19/27	1,434 2/27	1,564 4/9
One mile	9 feet wide	880	1,026 2/3	1,173 1/3	1,320	1,466 2/3	1,613 1/3	1,760
One mile	10 feet wide	977 7/9	1,140 20/27	1,303 19/27	1,466 2/3	1,629 17/27	1,792 16/27	1,955 5/9
One mile	11 feet wide	1,075 5/9	1,254 22/27	1,434 2/27	1,613 1/3	1,792 16/27	1,971 23/27	2,151 1/9
One mile	12 feet wide	1,173 1/3	1,368 8/9	1,564 4/9	1,760	1,955 5/9	2,151 1/9	2,346 2/3
One mile	13 feet wide	1,271 1/9	1,482 26/27	1,694 22/27	1,906 2/3	2,118 14/27	2,330 10/27	2,542 2/9
One mile	14 feet wide	1,368 8/9	1,597 1/27	1,825 5/27	2,053 1/3	2,281 13/27	2,509 17/27	2,787 7/9
One mile	15 feet wide	1,466 2/3	1,711 1/9	1,955 5/9	2,200	2,444 4/9	2,688 8/9	2,933 1/3
One mile	16 feet wide	1,564 4/9	1,825 5/27	2,085 25/27	2,346 2/3	2,607 11/27	2,868 4/27	3,128 8/9
One mile	17 feet wide	1,662 2/9	1,919 7/27	2,216 8/27	2,493 1/3	2,770 10/27	3,047 11/27	3,324 4/9
One mile	18 feet wide	1,760	2,053 1/3	2,346 2/3	2,640	2,933 1/3	3,226 2/3	3,520
One mile	19 feet wide	1,857 7/9	2,167 11/27	2,477 1/27	2,786 2/3	3,096 8/27	3,405 25/27	3,715 5/9
One mile	20 feet wide	1,955 5/9	2,281 13/27	2,607 11/27	2,933 1/3	3,259 7/27	3,585 5/27	3,911 1/9

*From report of Commissioner of Public Roads, N. J. 1907.

*TABLE OF SPECIFIC GRAVITY AND WEIGHT OF VARIOUS †SOLID ROCKS.

No. of samples tested.	Name.	Specific Gravity.			Weight per cu foot solid rock			W'ght per cubic yd. solid rock		
		Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.
3	Peridotite (trap)	3.55	3.25	3.40	221	203	212	2,984	2,741	2,862
124	Diabase (trap)	3.20	2.60	2.95	200	162	184	2,700	2,187	2,484
33	Diorite (trap)	3.35	2.70	2.85	209	168	178	2,821	2,268	2,403
60	Schist	3.20	2.65	2.90	200	165	181	2,700	2,227	2,443
11	Felsite	2.80	2.50	2.65	175	156	165	2,362	2,106	2,227
53	Quartzite	3.10	2.50	2.70	193	156	168	2,605	2,106	2,268
358	Limestone	3.10	2.00	2.65	193	125	165	2,605	1,687	2,227
106	Granite	3.00	2.00	2.65	187	125	165	2,524	1,687	2,227

*From U. S. Dept. of Agriculture, Bulletin No .388, p. 7.
†Crushed stone is about one-half as heavy, being about 50% void.

EXPERIMENTAL ROADS CONSTRUCTED BY THE OFFICE OF PUBLIC ROADS IN THE STATE OF ALABAMA. UP TO 1911.

Location.	Year.	Length.	Kind.	Cost.
Snow Hill	1906	4,461 feet	Macadam	$ 2,465.53
Uniontown	1906	5,500 feet	Macadam	2,677.06
Anniston	1907	4,141*feet	Macadam	2,889.85
Opelika	1908	950 feet	Macadam	591.50
Eufaula	1908	3,000 feet	Sand Clay	122.58
Seale	1908	2,330 feet	Sand Clay	334.28
Athens	1908	3,000†feet	Gravel	1,674.32
Birmingham	1909	about 1 m'e	Macadam‡	13,251.05
Union Springs	1909	2,200 feet	Sand Clay	183.51
Tyler-Salem	1910	4,300 feet	Sand Clay	1,628.40

*Square yards of surface.
†Excluding $82.32 cost of concrete culvert.
‡Tarred slag and macadam.

*TABLE SHOWING COMPARATIVE VALUE OF DIFFERENT PAVEMENTS.

Data for Table is average of ten replies to the inquiry sent out by the Department of Agriculture, Washington.

Pavement qualities.	Percentage.	Granite.	Sandstone.	Asphalt (sheet).	Asphalt (block).	Brick.	Macadam.	Creosoted wood.
Cheapness (first cost)	14	4.0	4.0	6.5	6.5	7.0	14.0	4.5
Durability	20	20.0	17.5	10.0	14.0	12.5	6.0	14.0
Ease of maintenance	10	9.5	10.0	7.5	8.0	8.5	4.5	9.5
Ease of cleaning	14	10.0	11.0	14.0	14.0	12.5	6.0	14.0
Low traction resistance	14	8.5	9.5	14.0	13.5	12.5	8.0	14.0
Freedom from slipperiness (average of conditions)	7	5.5	7.0	3.5	4.5	5.5	6.5	4.0
Favorableness to travel	4	2.5	3.5	4.0	3.5	3.0	3.0	3.5
Acceptability	4	2.0	2.5	3.5	3.5	2.5	2.5	4.0
Sanitary quality	13	9.0	8.5	13.0	12.0	10.5	4.5	12.5
Total number of points	100	71.0	73.5	76.0	79.5	74.5	55.0	80.0
Average cost per square yard, laid, 1905	----	$3.26	$3.50	$2.36	$2.29	$2.06	$0.99	$3.10

Favorableness to travel is dependent chiefly upon smoothness and freedom from dust and mud, secondarily upon the qualities composing "Acceptability."

Acceptability includes noise, reflection of light, radiation of heat, emission of unpleasant odors, etc. It chiefly concerns the pedestrian and the adjoining resident.

Cost per square yard includes concrete, but not excavation, curbing, etc.; except for macadam, which is not usually laid on concrete.

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*From U. S. Dept. Agr., Forest service circular No. 141, on Wood Paving in the United States.

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GEOLOGICAL SURVEY OF ALABAMA

EUGENE ALLEN SMITH, *State Geologist*

BULLETIN No. 12

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1910

COMPILED FROM MINERAL RESOURCES OF THE UNITED STATES.

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GEOLOGICAL SURVEY OF ALABAMA

EUGENE ALLEN SMITH, *State Geologist*

BULLETIN No. 12

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1910

COMPILED FROM MINERAL RESOURCES OF THE UNITED STATES.

By

CHARLES ARTHUR ABELE

MONTGOMERY, ALA.

THE BROWN PRINTING COMPANY, PRINTERS AND BINDERS

1912

LETTER OF TRANSMITTAL.

University, Ala., March, 1912.

Hon. Emmet O'Neal,

Governor of Alabama,

Montgomery, Ala.

Sir:—I have the honor to transmit herewith the manuscript of a report on the Mineral Production of Alabama for the year 1910, with the request that it be printed as Bulletin No. 12 of the Geological Survey of Alabama.

Very Respectfully,

EUGENE A. SMITH,

State Geologist.

GEOLOGICAL CORPS.

Eugene Allen Smith, Ph. D.------------------------State Geologist.
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-----------Clerk in charge of Statistics of Mineral Production.
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George Havens-----------------------------Epes, Tombigbee River.
J. M. Hodge-----------------------Newton, Choctawhatchie River.
W. G. Early------------------------------------Pera, Pea River
J. F. Hicks--------------------------------Beck, Conecuh River

From the records of daily observations of the gage readings at these places when extended through sufficient time, the calculations of available horsepower to be obtained from the different streams is made.

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PREFACE.

The statistics of all the minerals included in the following pages have been collected in cooperation with the United States Geological Survey, and have been compiled by Mr. Abele from advance chapters of the *Mineral Resources of the United States,* a publication of the Federal Survey.

The introductory and general matter in each of these articles has either been taken without change from the U. S. advance chapters or has been rearranged or condensed from these chapters, or entirely rewritten to suit it for our present purposes. In each case credit is given to the author.

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1910

ABRASIVES.

W. C. PHALEN.

Abrasive materials fall naturally into two classes—natural abrasives and artificial abrasives. The production of artificial abrasives has shown great increase since its beginning, less than 15 years ago, and the value of these abrasives produced in this country during the last two years has exceeded that of the natural abrasives.

Under the head of natural abrasives there are included the following materials: (1) Millstones and burrstones, (2) grindstones and pulpstones, (3) oilstones and scythestones, (4) emery, (5) abrasive garnet, (6) infusorial earth and tripoli, and (7) pumice.

PRODUCTION.

Alabama produced only a limited number of millstones in 1910.

BAUXITE.

W. C. PHALEN.

USES.

The chief uses of bauxite are (1) as raw material in the production of metallic aluminum; (2) in the manufacture of aluminum salts; (3) in the manufacture of artificial abrasives; and (4) in the manufacture of bauxite brick.

(1) The use of bauxite in the production of metallic aluminum is by far the most important of those enumerated above. A large part of the entire output of Arkansas is used in the metallic aluminum industry, and the figures of production from this State have shown phenomenal growth during recent years. A large part of the French product is also used in the manufacture of metallic aluminum.

(2) Only the purer bauxite is used in the manufacture of chemicals, such as alum, aluminum sulphate, and aluminum salts in general. Freedom from oxide of iron is essential in the material to be used in the chemical manufactures.

(3) Bauxite is used on a large scale in the manufacture of the artificial abrasive, alundum, at Niagara Falls. This abrasive is made in the electric furnace by fusing calcined bauxite. It is high in crystalline aluminum oxide, and virtually amounts to a form of artificial corundum. Its quality is under complete control, and hence it can be duplicated with ease in the various abrasive products, a factor of great importance in any successful abrasive industry. Alundum is particularly efficient in the grinding of steel.

(4) The use of bauxite in the manufacture of refractory brick has by no means reached a perfected stage, but it is understood that several manufacturers are now experimenting on processes in which it is admixed with other materials. The life of bauxite- brick linings is as yet undetermined, though it is known to exceed by far the life of silica or fire-clay brick. The high cost of raw material, as well as that of its manufacture, makes the ultimate cost of bauxite brick excessive as compared with that of the other two bricks mentioned.

PRODUCTION.

Alabama showed the greatest individual gain among the States, both as to quantity and value of product.

Production of bauxite in the United States, 1889-1910, by States, in long tons.

Year.	Georgia.	Alabama.	Arkansas.	Total.	Value.
1889	728	....	....	728	$2,366
1890	1,844	....	....	1,844	6,012
1891	3,301	292	....	3,593	11,675
1892	5,110	5,408	....	10,518	34,183
1893	2,415	6,764	....	9,179	29,507
1894	2,050	9,016	....	11,066	35,818
1895	3,756	13,313	....	17,069	44,000
1896	7,313	11,051	....	18,364	47,338
1897	7,507	13,083	....	20,590	57,652
1898	....	....	....	25,149	75,437
1899	15,736	14,499	5,045	35,280	125,598
1900	19,739		3,445	23,184	89,676
1901	18,038		867	18,905	79,914
1902	22,677		4,645	27,322	120,366
1903	22,374		25,713	48,087	171,306
1904	21,913		25,748	47,661	235,704
1905	15,173		32,956	48,129	240,292
1906	25,035		50,267	75,332	368,311
1907	....		....	97,776	480,330
1908	14,464		37,703	52,167	263,968
1909	22,227		106,874	129,101	679,447
1910	33,096		115,836	148,932	716,258

Production and value of Bauxite in Alabama in 1910.

Quantity Tons	Value	% of Total U. S. prod.	% of Total U. S. Value
9517	$38,068	5.31%	6.39%

CEMENT.

EUGENE A. SMITH.

Puzzolan or Slag Cement.

During the past four years only one establishment in Alabama has been engaged in the manufacture of slag cement, using the material from the furnaces about Birmingham. The production is included in the returns for Portland cement and cannot be given separately.

Portland Cement.

Alabama contains large supplies of limestone, chalk, clay and shale well adapted for Portland Cement manufacture, and widely distributed throughout the state. Coal and labor are abundant and cheap, transportation facilities are excellent, and many of the best limestone and chalk localities are situated on navigable rivers, giving ready access and cheap water transportation to Galveston, New Orleans, Mobile, Charleston, and other ports of the Gulf and Atlantic Coasts. This advantage of location will be immensely increased with the opening of the Panama Canal for cement plants located in Alabama will be more than a thousand miles nearer to the Isthmus than their nearest possible competitors.

The limestones and shales of the northern part of the state lie so close to each other, and above all so close to the great coal mines which must supply the fuel, that the establishment of Portland Cement plants near the coal mines would give to this industry in Alabama the same advantages which the proximity of the iron ore, the coal, and the stone has given to the iron industry, and which has placed our state beyond competition.

As a Portland cement mixture, ready for burning, consists approximately of 75 per cent. lime carbonate and 25 per cent. of clayey matter, the material furnishing the lime carbonate is necessarily of more economic importance than that from

which the silica and alumina are derived. In consequence, a Portland cement plant is usually located in the immediate vicinity of a suitable limestone, while the clay or shale required to complete the mixture may be brought some distance.

The limestone formations in North Alabama which can supply the stone adapted for use in cement manufacture are the Trenton or Pelham limestone and the Bangor or Subcarboniferous. In close proximity to both these limestone formations are the shales of the Clinton, Subcarboniferous and Coal Measures.

At the present time there are two cement plants in North Alabama, namely the Standard Portland Cement Co., located at Leeds in Jefferson County, and the Atlantic & Gulf Portland Cement Co., located at Ragland in St. Clair County. Both of these plants make use of the hard Trenton limestone, and the Standard Cement Co., according to Burchard of the U. S. Geological Survey, uses the shale of the Clinton formation whilst the Ragland Company makes use of the shales of the Coal Measures. Up to the present time no establishment is utilizing the Bangor limestone.

In Middle Alabama the soft, chalky Cretaceous limestone of the Selma Chalk, is the material utilized by the Alabama Portland Cement Co., at Spocari, near Demopolis. The same Company makes use of residual clays overlying and derived from the weathering of the Selma Chalk. During 1910 there was no production reported from the Demopolis plant.

In Southern Alabama the St. Stephens limestone outcropping east and west across the state, furnishes excellent material for Portland Cement manufacture, using either residual clays from decomposition of the limestone, or the clays of the Grand Gulf formation which are almost everywhere in close proximity to the limestone. The Mobile Cement Co. has been for some time engaged in the building of a plant at St. Stephens, but no production has yet been reported.

List of States Producing Puzzolan Cement, and Quantity and Value of Product from 1906 to 1910.

	1906	1907	1908	1909	1910
Number of plants reporting production:					
Alabama	2	1	1	1	1
Illinois	1	1	....	....	....
Kentucky	1	1	....	....	....
Maryland	1	....	....	....	....
New Jersey	1	....	....	....	....
New York	1	1	....	....	....
Ohio	2	2	2	2	2
Pensylavnia	1	1	1	1	1
Total	10	7	4	4	4
Production in barrels	481,224	557,252	151,451	160,646	95,951
Value of production	$412,921	$443,998	$95,468	$99,453	$63,286

Production and Value of Cement (Including Puzzolan and Portland) in Alabama in 1910.

Kind	No. of Producers	Quantity Produced. Bbl.	Value	Percentage of Total U. S. Value
Portland & Puzzolan....	3	406 214	$387,600	0.56%

CLAY AND CLAY PRODUCTS.

JEFFERSON MIDDLETON AND C. A. ABELE.

Clay available for the manufacture of clay products is one of the most widely spread of our minerals. Clay miners are usually also the manufacturers of the lower-grade clays, but as the higher grades of ware are reached the rule is that fewer and fewer manufacturers are also miners, until in the highest grades of ware the rule is that the manufacturer is not the miner of the clays that he uses. The figures given in the following tables represent clay that is mined and not manufactured by the miner, but is sold as clay. The clay thus sold is small in quantity compared with that consumed and includes mainly clay used for high-grade pottery, for paper making, and for refractory products.

The total quantity of clay mined in Alabama and sold as such in 1910 was 75,082 short tons, as compared with 63,408 short tons in 1909, an increase of 11,674 tons, or 18.41 per cent. The value of the clay mined in 1910 was $38,045, a decrease from 1909 of $2,887, or 7.05 per cent. Fire-clay showed an increase of 9,345 tons, or 20.7 per cent. in quantity, and a decrease of $2,950, or 8.34 per cent. in value. Miscellaneous clay, including brick clay, in 1910, increased in quantity 2329 tons, or 12.7 per cent.; and in value $63.00 or 1.12 per cent.

Quantity and Value of Clay Produced in 1910.

Kind	Quantity Produced. Tons.	Value	Avg. Value Per Ton	Percentage of Total U. S. Value
Fire Clay	54,482	$32,395	$0.594	1.5%
Miscellaneous Clay.....	*20,600	5,650	0.274	2.53%
Total	75,082	$38,045	$0.506	1.04%

*Includes brick clay; one producer.

Comparison of 1909 *and* 1910.

Kind	1909 Quantity Tons.	1909 Value	1910 Quantity Tons.	1910 Value	Increase or Decrease Quantity Tons.	Increase or Decrease Value	Increase or Decrease Percent (Value.)
Fire Clay	45.137	$35,345	54,482	$32,395	+ 9,345	—$2,950	—8.34%
Miscellaneous Clay	18.271	5,587	*20.600	*5,650	+ 2,329	+ 63	+1.12%
Total	63,408	$40,932	75,082	$38,045	+11,674	—$2,887	—7.05%

*Includes brick clay; one producer.

CLAY-WORKING INDUSTRIES.

The total value of the clay products in 1910 was $1,667.559, a decrease from 1909 of $32,568. or 1.9 per cent. The value of the brick and tile and fire-proof products was $1,645,313, or 98.66 per cent. of the total.

Value of Brick and Tile, and Potteries, 1906-1910.

ALABAMA.

Product.	1906	1907	1908	1909	1910
Brick:					
Common—					
Quantity	166,225.000	159,315,000	120,237,000	146,180.000	135,785,000
Value	$1,046,986	$1,004,644	$690,963	$799.693	$746.961
Average per M.	$6.30	$6.31	$5.75	$5.47	$5.50
Vitrified—					
Quantity	(*)	13,362,000	18,248,000	20,444,000	19,772,000
Value	(*)	$183,895	$244,084	$262,376	$236,516
Average per M	$11.62	$13.76	$13.38	$12.83	$11.96
Front—					
Quantity	(*)	(*)	(*)	(*)	(*)
Value	(*)	(*)	(*)	(*)	(*)
Average per M.	$11.35	$13.90	$17.89	$16.19	$15.95
Fancy value..	....	(*)	(*)	(*)	....
Fire do....	$157.147	$170,711	$122.354	$196,887	$163,672
Draintile do....	$2.285	(*)	$2.046	(*)	$3,773
Sewer pipe do....	(*)	(*)	(*)	(*)	(*)
Fireproofing do....	(*)	(*)	(*)	(*)	(*)
Pottery:					
Red earthenware....do....	$2.620	$7,530	$15,058	$11,886	$3,475
Stoneware and yellow and Rockingham ware. Value	$35.376	$20.215	$9,031	$24,453	$16.371
Miscellaneous value	$444,485	$367.414	$476,070	$404,832	$495,791
Total value	$1,688,899	$1,754,409	$1,559,606	$1,700,127	$1,667,559
Number of operating firms reporting	112	100	103	100	87
Rank of State	21	20	19	22	22

* Included in "Miscellaneous."

BRICK AND TILE.

The total number of common brick produced was 135,785 thousand, a decrease from 1909 of 10,395 thousand, or 7.11 per cent. The value was $746,961, a decrease of $52,736, or 6.59 per cent. The value of vitrified brick produced in 1910 was $236,516, a decrease from 1909 of $25,860, or 9.85 per cent. The values of common brick, vitrified brick, fire-brick, and fire-proofing decreased, while the values of front-brick, drain tile, sewer pipe, silica brick, and miscellaneous ware increased. Following is a table showing the production and values for 1910, and one showing the relation of the quantities produced and the values in 1910 to those of 1909:

Brick and Tile Producttion in 1910.

Style	Quantity M.	Value	Average Value per M.	Percentage of Total Alabama Brick & Tile	Percentage of Total U. S. Value.
Common Brick	135,785	$746,961	$5.50	45.39+%	1.35%
Drain Tile		3,773		0.23 %	0.036%
Vitrified Brick or Block.....	19,772	236,516	11.96	14.37+%	2.15%
Fire Brick	10,365	163,672	15.75	9.94+%	0.90%
Miscellaneous		*494,391		30.05 %	
Total		$1,645,313		100.00 %	1.21%

* Includes front brick, sewer pipe, fire proofing, and silica brick.

Comparison of Brick and Tile in 1909 *and* 1910.

	1909.			1910.				
	Quantity M.	Value	Average Price	Quantity M.	Value	Average Price	Increase or Decrease	Percent.
Common Brick	146,180	$799,693	$5.47	135,785	$746,961	$5.50	—$52,736	— 6.59
Vitrified Brick	20,444	262,376	12.83	19,772	236,516	11.96	— 25,860	— 9.85
Drain Tile		*			3,773			
Fire Brick	14,119	196,887	13.94	10,365	163,672	15.75	— 33,215	—16.87
Miscellaneous		†403,832			‡494,391			
Total		$1,663,788			$1,645,313		—$18,475	— 1.11

* Only one producer.
† Includes Front brick, Drain tile, Sewer pipe, Fire proofing and Silica brick.
‡ Includes Front brick, Sewer pipe, Fire proofing, and Silica brick.

POTTERIES.

Alabama produces only pottery of the commoner or coarser types, red and yellow earthenware, and even this is not produced in any quantity by the nineteen active firms in 1910, most of which produced for local trade only. There was a considerable decrease in production in 1910, the decrease amounting to $14,093, or 38,78 per cent.

Value of Pottery Products in 1910.

Kind.	Value.	Percentage of Total Alabama Potteries.	Percentag of Total U. S. Value
Red Earthen Ware	$3,475	15.62+%	0.41%
Stoneware and Yellow and Rockingham Ware	*18,771	84.38—%	0.33%
Total	$22,246	100.00 %	0.07%

* Includes miscellaneous ware.

Comparison of 1909 *and* 1910.

Kind.	1909	1910	Increase or Decrease.	Percent Decrease.
Red Earthen Ware	$11,886	$3,475	—$8,411	—70.76%
Stoneware and Yellow and Rockingham Ware	24,453	*18,771	—5,682	—23.23%
Total	$36,339	$22,246	—$14,093	—38.78%

* Includes miscellaneous ware.

COAL.

E. W. PARKER.

THE COAL FIELDS OF ALABAMA.

The Alabama coal fields form the southwestern end of the great Appalachian coal region, which extends from northern Pennsylvania to central Alabama. The coal-bearing formations narrow in Tennessee, but widen abruptly in northern Alabama and cover about 6,000 square miles in the northern half of the State. There are four distinct coal-producing basins in the State, the Coosa and the Cahaba basins and the Warrior and the Plateau fields. The first three areas mentioned derive their names from the rivers which drain them. The Plateau field includes Blount, Lookout, and Sand or Raccoon mountains.

The Coosa basin is a deep syncline forming the southeast margin of the Alabama coal fields and extending across Shelby and St. Clair counties. It is 60 miles long by 6 miles wide and contains about 350 square miles. This basin has not been thoroughly explored and the number and extent of its coal beds are not well known, but in different parts 2 to 12 beds are reported having a thickness of 3 feet or more.

The Cahaba basin is also a syncline west of the Coosa basin, to which it is parallel and from which it is separated by a

faulted anti-cline. It includes parts of St. Clair, Jefferson, Shelby, and Bibb counties. Its length is 68 miles, its average width about 6 miles, and its area 394 square miles. There are many workable beds, and the total quantity of coal in the basin is large.

The Warrior basin is separated from the Cahaba basin and Blount Mountain by Jones and Murphrees valleys. It includes all of Walker County, most of Jefferson, Tuscaloosa, and Fayette counties, and smaller parts of Blount, Cullman, Winston, and Marion counties. Its known area is estimated at 4,000 square miles. Around its western and southern margin, however, the higher rocks and coal beds pass under rocks of much later age, and have probably a considerable, and possibly a great, extent to the southwest of their visible margin.

The Warrior basin has always been the scene of the greatest mining activity and production in the State. Somewhat over one-third of the total production in the Birmingham district comes from the Pratt bed, and one-fourth comes from the Mary Lee bed. Eight or ten other beds furnish the remainder of the production.

The Plateau field embraces parts of Blount, Etowah, Dekalb, Cherokee, Marshall, and Jackson counties, and is upward of 3,000 square miles in extent. The Plateau and the Warrior fields are the southwest extension of the Cumberland plateau in Tennessee. The coal resources of the Plateau field are not well known, but they are comparatively small. There are believed to be from 4 to 6 beds that are locally workable.

From a productive point of view the most important of the coal beds in Alabama are the Pratt and the Mary Lee. These two beds, with the Blue Creek, furnish the coking coals which have made Alabama one of the important iron-making States. The Pratt bed is worked in Jefferson and Walker counties, and from it 3,931,248 short tons of coal were produced in 1909, and 4,493,451 tons in 1910. The Mary Lee also is worked in Jefferson and Walker counties, and the output from this bed amounted in 1909 to 3,276,167 short tons. In 1910 the production was 3,734,049 tons. The other beds which make important contributions to the coal production of Alabama are (1) the Blue Creek, worked in Jefferson and

Tuscaloosa counties, with a production in 1909 of 798,879 short tons, and in 1910 of 746,833 tons; (2) the Thompson, worked in Bibb and Shelby counties, whose production amounted to 678,478 short tons in 1909, and 1,330,457 tons in 1910; (3) the Black Creek, one of the most extensive beds in the State, worked in Blount, Cullman, Jefferson, Marion, Walker, and Winston counties, produced 676,908 short tons in 1909, and 766,923 tons in 1910; (4) the Brookwood, including the Milldale, worked in Tuscaloosa County, had a production in 1909 amounting to 674,661 short tons, and in 1910 to 578,453 tons; (5) the Corona, worked in Walker County, produced 514,774 short tons in 1909, and 524,046 tons in 1910; (6) the Jagger, worked in Walker County, had an output ot 507,032 short tons in 1909, and 1,183,404 tons in 1910; and (7) the American, worked in Jefferson and Walker counties, which in 1909 produced 272,717 short tons, and in 1910, 297,486 tons.

The other beds to which more or less local names have been given are the Buck (Clark, Blockton, No. 1, Woodstock), Cliff, Climax, Coal City, Black Shale (Gholson), Gould, Harkness, Helena, Howard, Jefferson, Mammoth, Maylene, Montevallo, Mount Carmel, Natural Bridge, Nickel Plate, Number One, Rutilia, Warrior, and Coke (Youngblood), with a few others. Some of these are probably duplicates, two names having been applied to the same bed, but they have not been correlated.

According to the estimates prepared by Marius R. Campbell, of the United States Geological Survey, the original coal supply of Alabama when mining began was 68,903,000,000 short tons, of which 63,513,000,000 tons were in the Warrior and Plateau fields, 2,994,000,000 tons were in the Cahaba field, and 2,396,000,000 tons in the Coosa field. From this total supply of approximately 69,000,000,000 tons there had been mined at the close of 1910, 206,153,815 tons, representing an exhaustion, including waste in mining, of 309,000,000 tons, or 0.4 per cent of the total estimated supply. A more recent estimate for the Coosa field by Wm. F. Prouty, assistant to the State geologist, is 80,921,000 tons; and by Chas. Butts, of the United States Geological Survey, for the Cahaba field, is 3,200,000,000 tons.

The production of coal in Alabama in 1910 was 7.8 per cent. of the total production up to the close of the year, and 0.02 of 1 per cent. of the estimated original supply.

PRODUCTION.

Total production in 1910, 16,111,462 short tons; spot value, $20,236,853.

In a preliminary review of the coal-mining industry in 1910, published as a press bulletin of the U. S. Geological Survey, early in January, 1911, it was stated that Alabama's production had reached the unprecedented total of 15,000,000 short tons Complete returns from all but a few mines whose aggregate output is less than 50,000 tons show that the preliminary figures were exceeded by a million tons, the output being 16,111,462 short tons. This unusually large tonnage (the largest previous production being 14,250,454 short tons in 1907) was due primarily to the strike in Illinois and other Western States, and secondarily to low water in Ohio and Kanawha rivers, which reduced shipments from Pennsylvania and West Virginia to Mississippi River points. The demand thus created for Alabama coal made up for the dullness in the iron market. This dullness was pronounced during almost the entire year and was still decidedly noticeable at the close of the year, with promise of continuation during 1911.

Compared with 1909, when the production amounted to 13,703,450 short tons, the output in 1910 showed an increase of 2,408,012 short tons, or 17.57 per cent. The conditions in 1910 naturally resulted in an advance in prices, and the total value increased from $16,306,236 to $20,236,853, a gain of $3,930,617, or 24.10 per cent. The average price per ton in 1910 was $1.26, against $1.19 in 1909.

The coal mines of Alabama were practically free from strikes in 1910, there being only 25 men idle from that cause during the year. The average time lost by the 25 men was 50 days. The labor supply, although short in places, was, on the whole, satisfactory. In some parts of the State the car supply was reported the best in several years, but in other sections quite the reverse was reported.

The coal-mining industry of Alabama was marred during 1910 by two bad disasters which together cost the lives of 131 men. The first occurred on April 20 at the Mulga mine and cost 40 lives; the second was at the Palos mine, on May 5, and cost 91 lives. The number of fatalities in these two accidents was more than the total number of deaths from all causes in either 1908 or 1909. According to the report of the chief mine inspector of the State, the total number of fatal accidents in 1910 was 238, against 129 in 1909 and 108 in 1908. The death rate per thousand in 1910 was 10.7 and the number of tons mined for each life lost was 67,695; in 1909 the death rate was 6.4 and there were 106,228 tons mined for each life lost.

The number of men employed in the coal mines of Alabama in 1910 was 22,230, who worked an average of 249 days, chiefly of 10 hours. The average production per man was 725 short tons for the year and 2.91 tons for each working day.

The number of mining machines reported in 1910 was 317, and the quantity of machine-mined coal was 2,980,122 short tons, or 18.50 per cent. of the total. In 1909, 283 machines were used in the production of 2,203,619 tons, or 15.02 per cent of the total. There were 6,772,860 short tons of coal washed in 1910, yielding 5,971,305 tons of cleaned coal and 801,555 tons of refuse.

The statistics of coal production in Alabama in 1909 and 1910, with the distribution of the product for consumption, are shown in the following table:

Coal Production of Alabama in 1909 *and* 1910, *by counties, in short tons.*

1909.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke	Total quantity.	Total value.	Average price per ton.
Bibb	1,227,614	5,736	104,501	392	1,338,243	$1,791,805	$1.34
Etowah	44,416	238	1,540	....	46,194	59,869	1.30
Jefferson	3,873,937	106,305	247,099	2,949,581	7,176,922	8,222,061	1.15
St. Clair	336,072	1,336	16,597	....	354,005	460,640	1.30
Shelby	489,190	3,746	31,989	....	524,925	838,595	1.60
Tuscaloosa	648,731	9,311	44,431	304,516	1,006,989	1,158,484	1.15
Walker	2,585,006	57,749	82,538	248,483	2,973,776	3,387,988	1.14
Winston	26,578	5,700	....	....	32,278	48,489	1.50
Other counties*..	235,401	6,451	7,806	....	249,658	337,464	1.35
Small mines	....	460	....	....	460	841	1.83
Total	9,466,945	197,032	536,501	3,502,972	13,703,450	16,306,236	1.19

* Blount, Cullman, DeKalb, Jackson, and Marion.

1910.

County	Loaded at mines for shipment.	Sold local trade & used by employees	Used at mines for steam and heat	Made into coke	Total quantity.	Total value.	Av. price per ton.	Av. No. days active	Average No. of Employes.
Bibb	1,462,720	6,961	110,883	....	1,580,564	$2,370,919	$1.50	261	2,666
Etowah	169,251	1,538	1,676	....	172,465	254,798	1.48	251	388
Jefferson	4,289,536	109,377	329,777	3,570,012	8,298,702	10,247,456	1.23	255	10,832
St. Clair	411,247	2,398	14,764	....	428,409	571,675	1.33	234	524
Shelby	450,324	3,381	34,436	....	488,141	780,887	1.60	253	847
Tuscaloosa ..	412,144	6,842	54,498	607,735	1,081,219	1,232,495	1.14	264	1,496
Walker	3,395,104	66,561	87,118	239,696	3,788,479	4,395,910	1.16	227	4,889
Winston	16,192	250	......	....	16,442	25,370	1.54	156	57
Other counties* ..	237,293	8,583	10,855	....	256,731	356,723	1.39	241	531
Small mines..	....	310	......	....	310	620	2.00	....	.....
Total ..	10,843,811	206,201	644,007	4,417,443	16,111,462	20,236,853	1.26	249	22,230

* Blount, Cullman, Dekalb, Jackson, and Marion.

In the following table is presented a statement of the production of coal, in Alabama, by counties, during the last five years, with increases and decreases in 1910 as compared with 1909:

Coal Production of Alabama, 1906-1910, by Counties, in short tons.

County.	1906	1907	1908	1909	1910	Increase (+) or decrease (—), 1910.
Bibb	1,324,656	1,297,158	1,166,548	1,338,243	1,580,564	+ 242,321
Blount						
Cullman	*337,848	336,308	181,062	186,261	235,456	+ 49,195
Etowah	133,660	205,015	8,880	46,194	172,465	+ 126,271
Jefferson	6,623,115	7,526,275	5,914,129	7,176,922	8,298,702	+ 1,121,780
St. Clair	256,227	283,806	193,434	354,005	428,409	+ 74,404
Shelby	225,087	245,087	407,547	524,925	488,141	— 36,784
Tuscaloosa	1,050,792	1,047,364	712,101	1,006,989	1,081,219	+ 74,230
Walker	3,062,518	3,254,919	2,941,836	2,973,776	3,788,479	+ 814,703
Winston	27,076	35,333	28,408	32,278	16,442	— 15,836
Other counties and small mines	66,984	19,189	50,648	63,857	21,585	— 42,272
Total	13,107,963	14,250,454	11,604,593	13,703,450	16,111,462	+ 2,408,012
Total value.	$17,514,786	$18,405,468	$14,647,891	$16,306,236	$20,236,853	+$3,930,617

* Includes production of Marion County.

So far as known, the earliest record of the existence of coal in Alabama was made in 1834. The first statement of production in the State is contained in the United States census report for 1840, in which year the production is given as 946 tons. The census report for 1850 does not mention any coal production for the State, and the next authentic record is contained in the census statistics of 1860, when Alabama is credited with an output of 10,200 short tons The mines of Alabama were probably worked to a considerable extent during the Civil War, but there are no records of the actual production until 1870, for which year the United States census reports a production of 11,000 tons. Ten years later the production had increased to 323,972 short tons, but the development of the present great industry really began in

1881 and 1882, when attention was directed to the large iron deposits near the city of Birmingham, and thus the great "boom" of that city and vicinity was inaugurated. By 1885 the coal production of the State had increased to nearly 2,500,000 tons Then followed a period of relapse and liquidation, which lasted two years, after which business settled down to a conservative and rational basis and has since developed steadily. In 1902 the coal production of the State reached a total of over 10,000,000 tons, and reached the maximum of 16,111,462 tons in 1910.

The statistics of production in Alabama from 1840 to the close of 90 are found in the following table:

Production of Coal in Alabama from 1840 *to* 1910, *in short tons.*

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1840.....	946	1859.....	9,000	1878.....	224,000	1897.....	5,893,770
1841.....	1,000	1860.....	10,200	1879.....	280,000	1898.....	6,535,283
1842.....	1,000	1861.....	10,000	1880.....	323,972	1899.....	7,593,416
1843.....	1,200	1862.....	12,500	1881.....	420,000	1900.....	8,394,275
1844.....	1,200	1863.....	15,000	1882.....	896,000	1901.....	9,099,052
1845.....	1,500	1864.....	15,000	1883.....	1,568,000	1902.....	10,354,570
1846.....	1,500	1865.....	12,000	18854....	2,240,000	1903.....	11,654,324
1847.....	2,000	1866.....	12,000	1885.....	2,492,000	1904.....	11,262,046
1848.....	2,000	1867.....	10,000	1886.....	1,800,000	1905.....	11,866,069
1849.....	2,500	1869.....	10,000	1887.....	1,950,000	1906.....	13,107,963
1850.....	2,500	1869.....	10,000	1888.....	2,900,000	1907.....	14,250,454
1851.....	3,000	1870.....	11,000	1899.....	3,572,983	1908.....	11,604,593
1852.....	3,000	1871.....	15,000	1890.....	4,090,409	1909.....	13,703,450
1853.....	4,000	1872.....	16,800	1891.....	4,759,781	1910.....	16,111,462
1854.....	4,500	1873.....	44,800	1892.....	5,529,312		
1855.....	6,000	1874.....	50,400	1893.....	5,136,935	Total..	206,153,815
1856.....	6,800	1875.....	67,200	1894.....	4,397,178		
1857.....	8,000	1876.....	112,000	1895.....	5,693,775		
1858.....	8,500	1877.....	196,000	1896.....	5,748,697		

The following table shows the rank of Alabama in 1909 and 1910, among the ten leading coal-producing states:

Rank of first ten coal-producing States in 1909 and 1910, with quantity and value of product and percentage of each.

1909.

Production.				Value.			
Rank.	State or Territory.	Quantity. (short tons)	% of total prodn.	Rank.	State or Territory.	Value.	% of total value.
1	Pennsylvania:			1	Pennsylvania:		
	Anthracite	81,070,359	17.6		Anthracite	$149,181,587	26.9
	Bituminous	137,966,791	29.9		Bituminous	130,085,237	23.4
2	West Virginia ...	51,849,220	11.2	2	Illinois	53,522,014	9.6
3	Illinois	50,904,990	11.0	3	West Virginia	44,661,716	8.1
4	Ohio	27,939,641	6.1	4	Ohio	27,789,010	5.0
5	Indiana	14,834,259	3.2	5	Alabama	16,306,236	2.9
6	Alabama	13,703,450	3.0	6	Indiana	15,154,681	2.7
7	Colorado	10,716,936	2.3	7	Colorado	14,296,012	2.6
8	Kentucky	10,697,384	2.3	8	Iowa	12,793,628	2.3
9	Iowa	7,757,762	1.7	9	Kansas	10,083,384	1.8
10	Kansas	6,986,478	1.5	10	Kentucky	10,079,917	1.8

1910.

Production.				Value.			
Rank.	State or Territory.	Quantity. (short tons)	% of total prodn.	Rank.	State or Territory.	Value.	% of total value.
1	Pennsylvania:			1	Pennsylvania:		
	Anthracite	84,485,236	16.8		Anthracite	$160,275,302	25.5
	Bituminous	150,521,526	30.0		Bituminous	153,029,510	24.3
2	West Virginia	61,671,019	12.3	2	West Virginia ...	56,665,061	9.0
3	Illinois	45,900,246	9.1	2	Illinois	52,405,897	8.3
4	Ohio	34,209,668	6.8	4	Ohio	35,932,288	5.7
5	Indiana	18,389,815	3.7	5	Indiana	20,813,659	3.3
6	Alabama	16,111,462	3.2	6	Alabama	20,236,853	3.2
7	Kentucky	14,623,319	2.9	7	Colorado	17,026,934	2.7
8	Colorado	11,973,736	2.4	9	Kentucky	14,405,887	2.3
9	Iowa	7,928,120	1.6	9	Iowa	13,903,913	2.2
10	Wyoming	7,533,088	1.5	10	Wyoming	11,706,187	1.9

COKE.

E. W. PARKER.

The most significant feature of the coke-making industry in Alabama, as in most of the coke-producing States in 1910, was the advance in values. The quantity of coke produced in 1910 was not materially larger than in 1909, the increase being 163,203 short tons, or 5.3 per cent, from 3,085,824 short tons to 3,249,027 short tons, but with the improved demand prices advanced from an average of $2.61 per ton in 1909 to $2.82 in 1910, and the total value increased from $8,068,267 to $9,165,821, a gain of $1,097,554, or 13.6 per cent. In quantity the production of coke in Alabama in 1910 was the largest ever made, but the value of the 1910 product was about $50,000 less than that of 1907.

Reference has been made in previous reports to the advantages possessed by Alabama in having in the iron-making district of Birmingham a home market for its output of coke. Until the last few years Alabama and West Virginia were close rivals for second place among the coke-producing States, Pennsylvania of course being first. Since 1905 West Virginia has outstripped Alabama in the quantity of coke produced, and in 1910 made 3,803,850 short tons of coke as compared with 3,249,027 tons made in the Alabama ovens. Little of West Virginia's coke is, however, supplied to local markets. Probably 98 per cent. is shipped out of the State to furnish fuel to distant iron furnaces. The effect is shown by comparisons that may be made between the values of Alabama and West Virginia cokes, for whereas the quantity of coke made in West Virginia in 1910 exceeded the Alabama product by 554,823 short tons, the value of Alabama's coke exceeded that of West Virginia by $1,811,782. The average price of Alabama coke in 1910 was $2.82; that of West Virginia was $1.93.

Of the total quantity of coke made in 1910 in Alabama, 557,148 short tons were produced in by-product retort ovens, of which there are two establishments, with a total of 280 ovens in the State. The quantity of coal used in the retort ovens was 769,212 short tons, indicating a yield of coal in coke of 72.4 per cent. The average yield in coke made

by the beehive ovens was 59.8 per cent. During 1910 construction was begun on a bank of 60 Koppers by-product recovery ovens at Woodward by the Woodward Iron Co., and the Tennessee Coal, Iron & Railroad Co. began the construction of 280 ovens of the same type at Corey. These were the only new ovens under construction in the State at the close of the year.

There were 43 establishments in Alabama in 1910, the same number as in 1909. The total number of ovens increased from 10,061 in 1909 to 10,132 in 1910. These do not include the 340 Koppers ovens under construction at the close of 1910. Of the 43 establishments 5, with a total of 518 ovens, were idle during the entire year 1910. In 1909 there were 6 establishments with a total of 713 ovens idle throughout the year. The average production from the 9,614 ovens that were in operation in 1910 was 338 short tons; in 1909 the average production per oven was 330 tons.

The principal coal beds of Alabama which furnish the coal for coke making are the Pratt, the Mary Lee, and the Blue Creek, all of which are in the Warrior Basin, and the mining operations are in Jefferson, Walker, and Tuscaloosa counties. Some coking coal is also produced from the Buck or Blocton No. 1 bed, in Bibb County.

The production of coke in Alabama in 1880, 1890, 1900, and from 1906 to 1910 is shown in the following table:

Statistics of the manufacture of coke in Alabama, 1880-1910.

Year.	Establishments.	Ovens.		Coal used (short tons.)	Coke produced (short tons.)	Total value of coke at ovens.	Value of coke at ovens (per ton.)	Yield of coal in coke (per cent.)
		Built.	Building.					
1880	4	316	100	106,283	60,781	$183,063	$3.01	57.0
1890	20	4,805	371	1,809,964	1,072,942	2,589,447	2.41	59.0
1900	30	6,529	690	3,582,547	2,110,837	5,629,423	2.67	58.9
1906	42	9,731	160	5,184,597	3,034,501	8,477,899	2.79	58.5
1907	43	9,889	50	4,973,296	3,021,794	9,216,194	3.05	61.0
1908	45	10,103	0	3,875,791	2,362,666	7,196,901	3.04	61.0
1909	43	10,061	0	5,080,764	3,085,824	8,068,267	2.61	60.7
1910	43	*10,132	†340	5,272,322	3,249,027	9,165,821	2.82	61.6

* Includes 280 Semet-Solvay ovens. † Koppers by-product ovens.

About 60 per cent of the coal made into coke in Alabama in 1910 was washed slack. The total quantity of coal made into coke in 1910 was 5,272,322 short tons, of which 3,192,306 tons were washed slack. Of the other, 2,080,016 tons, 1,308,-085 tons were run-of-mine coal crushed and washed before coking, and 771,931 tons were unwashed mine-run coal. The total quantity of washed coal used was 4,500,391 short tons, or 86 per cent. of all the coal made into coke.

The character of the coal used in the manufacture of coke in Alabama in 1890, 1900, and for the last five years, is shown in the following table:

Character of coal used in the manufacture of coke in Alabama, 1890-1910, in short tons.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
1890	1,480,669	0	206,106	123,189	1,809,964
1900	1,729,882	152,077	165,418	1,535,170	3,582,547
1906	1,493,549	1,810,089	121,122	1,759,837	5,184,597
1907	1,020,907	1,697,913	27,433	2,227,043	4,973,296
1908	548,093	1,457,360	53,218	1,817,120	3,875,791
1909	713,992	2,153,801	0	2,212,971	5,080,764
1910	771,931	1,308,085	0	3,192,306	5,272,322

Below is a list showing the rank of the first five of the States producing coke in 1906-1910.

Rank of the first five States in production of coke, 1906-1910.

State or Territory	1906	1907	1908	1909	1910
Pennsylvania	1	1	1	1	1
West Virginia	2	2	2	2	2
Alabama	3	3	3	3	3
Illinois	14	10	9	5	4
Virginia	4	4	4	4	5

Comparison of production and value of coke in Alabama. 1909 and 1910.

	No. of Ovens.	Coal Charged short tons	Coke Produced short tons	Total value of Coke at Ovens.	Percent. of total U.S. value
1909	10,061	5,080,764	3,085,824	$8,068,267	8.97%
1910	10,132	5,272,322	3,249,027	$9,165,821	9.19%
Increase	71	191,551	163,203	$1,097,554	
Prcentage Increase..	.705%	3.77%	5.26%	13.60%	

GOLD AND SILVER.

H. D. M'CASKEY.

The mine production of gold in Alabama in 1910 was 1,622.16 fine ounces, valued at $33,533, and that of silver was 268 fine ounces, valued at $145. These figures show an increase in value of gold output for Alabama of $4,294, and an increase in silver output of 56 fine ounces in quantity and of $35 in value. The silver production is entirely from recovery of this metal in refining the gold. No copper ores were mined in 1910.

The production of gold and silver in Alabama in 1910 was reported from 3 deep mines and 3 gold placers. The total placer gold, all from Mud and Clear creeks, in Cleburne County, was valued at $357 in 1910, as against $69 in 1909. The deep-mine production was from 9,763 short tons of ore, with an average recoverable value per ton in gold and silver of $3.41. In 1909 the ore production was 9,886 short tons, but the recoverable value per ton was only $2.96.

The output in 1910 was again almost wholly from the Hog Mountain mines in Tallapoosa County. The siliceous ores of this mine are in part oxidized and in part sulphides, and they are treated in a 120-ton cyanide plant. There was a nominal output of gold from the Gold Ridge mines in Randolph County, and development work at the Story pros-

pect in Talladega County yielded a small amount of siliceous smelting ore which was shipped. Dump material was also treated at this property by amalgamation in a 5-stamp mill. Operations continued for only three months in 1910. Development work was done at the Holly mines near Dadeville in Tallapoosa County.

Gold and Silver production in 1909 *and* 1910.

	Gold.		Silver.		
	Value.	Percentage of total U. S. Value	Quantity oz.	Value.	Percentage of total U. S. Value
1909	$29,239	0.029%	212	$110	0.00035%
1910	33,533	0.035%	268	145	0.00046%
Increase	4,294		56	35	
Percentage	14.68%		26.37%	31.82%	

GRAPHITE.

EUGENE A. SMITH.

This substance is very generally distributed among the metamorphic or crystalline rocks, and it occurs in two modes. In the feebly crystalline schists or slates which we have called the Talladega, and which in part, at least, are paleozoic sediments, of as late age as the Coal Meansures, the graphite is vcery often found as a sort of black graphitic clay free from grit and is frequently used as a lubricant. In this condition the graphite is very difficult to separate from the other matters with which it is mixed. Examples of this mode of occurrence are to be seen near Millerville, in Clay County, and about Blue Hill and Gregory Hill in Tallapoosa.

In the mica schists and other fully crystalline rocks of this region the graphite is present in the form of thin flakes, or *lamellae,* and is comparatively easy to separate from the enclosing rock. This variety of graphite has been worked at several points in Clay, Coosa, and Chilton Counties.

In Tallapoosa County a mile below Tallassee there is a third mode of occurrence, or perhaps a modification of the second

above described. Here a belt of garnetiferous schist crosses the river in an outcrop of about 100 yards width. In this schist the graphite is found in lenses or flakes which sometimes attain a diameter of two inches. As the rock disintegrates the graphite lenses weather out and are scattered loose over the surface. The same belt or a similar one is to be seen where it crosses Wolf Creek in the northern part of Macon County.

During 1910 only two companies produced graphite in Alabama, viz.: (1) The Allen Graphite Co., whose plant is located about eight miles west of Ashland at "Graphite." (This Company was acquired in 1911 by the Quenelda Graphite Co.) (2) The Ashland Graphite Co., successor to the Enitachopco Graphite Co., whose quarry and mill are located about 4 1-2 miles west of Ashland. The graphite bearing rock at both places is a much decomposed schist consisting mainly of quartz and graphite. The character of the original rock is very difficult to determine.

This belt of graphitic schist can be followed southwestward through Coosa into Chilton County. Very promising occurrences have been noted in the vicinity of Goodwater and Hollins and near the Coosa River about Dollar P. O. in Coosa County, and across the river in Chilton County at one or two localities near Mountain Creek on the L. & N. R. R. In former years the Dixie Graphite Co. and the Flaketown Graphite Co. in this section were credited with some production of graphite, but they were idle during 1910.

In the Mineral Resources of the United States Geological Survey for the year 1910 a full account by Mr. Edson S. Bastin is given of the graphite producing plants in Clay County, together with rather full notices of the Dixie and Flaketown companies. To this article the reader who is interested in the possibilities of Alabama in this particular is referred.

Production and Value of Crystalline Graphite in Alabama in 1910.

Quantity.	Value.	Percent of total U. S. Production	Percent of total U. S. Value.
1,577,997 lbs.	$54,688	2.03%	14.49

IRON ORE.

EUGENE A. SMITH.

Iron ores of Alabama in the order of their economic importance are (1) red ore or hematite; (2) the brown ore or limonite; (3) the gray ore. The black band and clay iron stone have been noticed as occurring in a number of places, but only the red ore and the brown ore have been mined on any large scale.

Practically all the ore mined in Alabama is smelted in the State, the shipments out of the State being about equal to those received from other states.

The tables given below will show the rank of Alabama among the States of the Union both in the production of iron ore and in pig iron, and will show also the quantity of iron produced by charcoal and by coke respectively as fuels.

Red Ore or Hematite.

Practically all the ore of this quality mined in Alabama occurs in the Clinton or Red Mountain formation. The Red Mountain ridges occur on each side of the anticlinal valleys which separate the coal fields. In places the red ore ridges are lacking on one side, usually the western, of the valleys being cut out by faults, while on the other hand the ridge may be duplicated on one side of the valley by the same faults.

In most of the valley occurrences the moderate dips of the ore bed are on the eastern side and there are also practically all of the ore mines. Murphrees Valley makes an exception to this, the moderate dips and the iron mines being on the western side. The iron ore occurs mainly in the central part of the formation in seams or beds one to five in number, which vary in thickness from a few inches to thirty feet.

While the ore seams are very persistent along the outcrop which in Alabama must be as much as 50 miles, yet they vary

greatly from place to place, being either too thin or too lean for profitable working in the greater part of this distance.

The most important development of the Clinton ore in this State and in the world is along the 15 or 16 mile stretch of the east Red Mountain between Birmingham and Bessemer, and there is a practically continuous series of mines and strippings for this entire distance. Much mining of this ore has also been done near Gate City, Village Springs, Attalla, Gadsden, Round Mountain, Gaylesville, Ft. Payne, Valley Head, etc.

Production and Value of Hematite in Alabama in 1909 *and* 1910.

	Quantity. Tons.	% of total U.S. Prod.	Value.	% of total U.S. Value
1909	3,176,416	6.87%	$3,389,206	3.38%
1910	3,678,139	7.12%	4,376,555	3.39%
Increase	501,723		987,349	
Percent.	15.79%		29.13%	

The average price per long ton of hematite ore in Alabama was, in 1909, $1.07; in 1910, $1.19.

Brown Ore or Limonite.

This ore, the second in importance in the State and in the United States, furnished only 5.04 per cent of the total iron ore production of the United States in 1910. Of this Alabama produced 39.15 per cent., 1,123,136 long tons, and the State holds the *first* rank in this industry.

In the early days of iron making and up to the year 1876 this was the only ore used in the catalan forges, bloomaries, and charcoal furnaces of the State. It was then demonstrated that good iron could be made at low cost from the red ores, with coke for the fuel.

In general the limonites are considered the best of the ores of Alabama and they command the highest prices and command a ready sale.

The usual mode of occurrence is in irregular masses of concretionary origin in the residual clays resulting from the decomposition of limestones, and as a consequence the mining is uncertain and expensive. Limonite also occurs in regu-

larly stratified seams or beds, and then it is the result of the alteration of pyrites or of carbonate ores. Practically all of the brown ore actually mined is that occurring in the residual clays above mentioned. Most of the ore before going to the furnace is washed and screened, and this manipulation, together with the cost of mining, makes it the most expensive of the iron ores, and it is therefore seldom used alone, but is usually mixed with the red ore in proportions determined by the quality of the iron desired. It is used alone in the charcoal furnaces and also in the coke furnaces when a particularly tough pig iron is wanted.

The limonite deposits are very numerous and are distributed over a broad expanse of country and in many places are known to be very extensive. In some of the deposits the ore is in nearly solid mass, in others it is much scattered, and in consequence the amount of foreign material necessary to be moved for every ton of ore produced, varies very much, not only in the different ore banks but also in the different parts of the same bank.

The deposits occur in nearly all the geological formations of the state, but in most of these the ore is either insufficient in quantity or not pure enough to be of much commercial value. The most important of the deposits, in point of extent and value, occur overlying the following formations, viz., the Knox Dolomite and the Weisner Quartzite, the Lauderdale Chert of the Lower Carboniferous, and the Lafayette. Some extensive beds of ore of inferior quality generally, occur also in the Tuscaloosa formation of the Cretaceous, and in the upper part of the Lower Carboniferous and in the Metamorphic rocks.

The average price per long ton of limonite in Alabama was in 1909, $1.41; in 1910, $1.53.

Production and Value of Brown Ore in Alabama in 1909 *and* 1910.

	Quantity.	% of total U.S. Prod.	Value.	% of total U.S.Value
1909	1,144,836	42.39%	$1,607,249	35.43%
1910	1,123,136	39.15%	1,707,167	35.28%
Increase or Decrease	—21,700		+$99,918	
Percent	—1.88%		+6.21%	

In the following table the States are arranged according to their rank as producers in 1909 and 1910, with regard to both the quantity and the value of the iron ore produced:

Rank of first five iron-ore producing States in 1909 and 1910, with quantity and value of product and percentage of each.

1909.

Rank	State.	Production.		Rank	State.	Value.	
		Quantity, in long tons.	Percentage of total product'n			Amount.	Percentage of total value.
1	Minnesota	28,975,149	56.64	1	Minnesota	$60,253,314	54.79
2	Michigan	11,900,384	23.26	2	Michigan	32,282,622	29.36
3	Alabama	4,321,252	8.45	3	Alabama	4,996,455	4.54
4	Wisconsin	1,067,436	2.09	4	New York	3,072,323	2.79
5	New York	1,015,333	1.98	5	Wisconsin	2,727,406	2.48

1910.

Rank	State.	Quantity, in long tons.	Percentage of total product'n	Rank	State.	Amount.	Percentage of total value.
1	Minnesota	31,966,769	56.19	1	Minnesota	$78,462,560	55.75
2	Michigan	13,303,906	23.39	2	Michigan	41,393,585	29.41
3	Alabama	4,801,275	8.44	3	Alabama	6,083,722	4.32
4	New York	1,287,209	2.26	4	New York	3,848,683	2.74
5	Wisconsin	1,149,551	2.02	5	Wisconsin	3,610,349	2.57

Production of Iron Ore in Alabama in 1909 and 1910.

	Hematite (long tons)	Brown ore (long tons)	Total Quantity.	Value.	% of total U. S. Value.
1909	3,176,416	1,144,836	4,321,252	$4,996,455	4.54
1910	3,678,139	1,123,136	4,801,275	$6,083,722	4.32
Increase or Decrease ...	+501,723	—21,700	+480,023	+$1,087,267	
Per cent	+15.79	—1.89	+11.11	+21.67	

Kinds of Ore Produced in Alabama, and Values of same in 1909 and 1910.

	Hematite				Brown Oore				Total.		Percent of U. S. Total	
	Quantity long tons	% of total	Value	% of total	Quantity long tons	% of total	Value	% of total	Quantity long tons	Value	Quantity	Value
1909	3,176,416	73.72	$3,389,206	67.85	1,144,836	26.26	$1,607,249	32.15	4,321,252	$4,996,455	8.44	4.54
1910	3,678,139	76.6+	$4,376,555	71.93+	1,123,136	23.39+	$1,707,167	28.07+	4,801,275	$6,083,722	8.43	4.32
Increase or Decrease	+501,723		+$987,349		—21,700		+$99,918		+480,023	+$1,087,267		
Per cent	+15.79%		+29.13%		—1.88%		+6.21%		+11.11%	+21.76%		

Rank of Groups producing over* 50,000 *Tons.
(Alabama Mines.)

	Name of Mine.	Nearest Town	Variety of ore	Quantity.
1	Red Mountain Group..	Bessemer	Hematite	1,769,067
2	Woodward	Woodward	Hematite	456,959
3	Songo	Birmingham	Hematite	189,527
4	Crudup	Gadsden	Hematite	164,250
5	Greeley	Greeley	Brown Ore	145,210
6	Woodstock	Woodstock	Brown Ore	127,647
7	Raimund No. 1.	Bessemer	Hematite	118,675
8	Raimund No. 2	Bessemer	Hematite	100,741
9	Steinman	Birmingham	Hematite	78,557
10	Houston	Woodstock	Brown Ore	75,554
11	Champion	Oneonta	Brown Ore	67,024
12	Spalding	Birmingham	Hematite	58,750
13	Stegmiller	Birmingham	Hematite	54,403
14	Tecumseh	Tecumseh	Brown Ore	50,964
			Total	3,457,318

PIG IRON AND STEEL.

The following table shows the quantity and approximate value of pig iron production in the United States in 1909 and 1910, and the increase or decrease, both by totals and percentages, for the first five producing States:

Quantity and value of pig iron produced in the United States in* 1909 *and* 1910 *by first five States, in long tons.

	State	1909		1910		Increase (+) decrease (—) in 1910.		Percentage increase (+) or decrease (—) in 1910.	
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value
1	Penn'a. ...	10,918,824	$175,429,000	11,272,323	$180,695,338	+353,499	+$5,266,338	+ 3.24	+ 3.00
2	Ohio	5,551,545	93,321,000	5,752,112	88,122,356	+200,567	— 5,198,644	+ 3.61	— 5.57
3	Illinois	2,467,156	44,211,000	2,675,646	42,917,362	+208,490	— 1,293,638	+ 8.45	— 2.93
4	Alabama .	1,763,617	22,222,000	1,939,147	23,754,551	+175,530	+ 1,532,551	+ 9.95	+ 6.90
5	New York	1,733,675	27,392,000	1,938,407	32,410,165	+204,732	+ 5,018,165	+11.81	+18.32

Production of pig iron in Alabama, 1907-1910.

J. M. Swank.

	Coke Pig Iron Long tons	Charcoal Pig Iron Long tons	Total Long tons
1907	1,651,533	35,141	1,686,725
1908	1,373,199	23,815	1,397,014
1909	1,729,976	33,641	1,763,617
1910	1,903,443	35,704	1,939,147
1911	1,679,886	32,557	1,712,443

Alabama Production of Rolled Iron and Steel (including Rolled Forging Blooms and Rolled Forging Billets) from 1907 *to* 1910 *inclusive.*

J. M. Swank.

Year.	Iron	Steel	Total
1907	44,728	238,569	283,297
1908	4,417	269,235	273,652
1909	1,267	256,705	257,972
1910	6,419	420,052	426,471

LIME.

C. A. ABELE.

The total production of fourteen operators in 1910 was 81,696 short tons, an increase over 1909 of 6,428 tons or 8.54 per cent. The value of the product was $303,612, an increase of 13,553, or 4.67 per cent.

Production and value of lime in 1909 and 1910, and a comparison of these years:

Production of Lime in 1909 *and* 1910.

	No. of Operators.	Quantity Short tons	Value.	Av'g price per ton.	Percentage of total U. S. Value.
1909	16	75,268	$290,059	$3.85	2.08%
1910	14	81,696	$303,612	$3.72	2.19%
Increase	......	6,428	$13,553	....	....
Percentage	......	8.54%	4.67%	....	....

The most important use of the lime produced in this State is for building purposes, though a large percentage is used in chemical plants, sugar refineries, etc., or is handled by dealers. Though at present only a small part of the Alabama production is used in chemical processes, this use may in time create a greater market in this State.

Below is an outline of some of the chemical processes in which lime may be used.

Chemical Uses of Lime.

E. F. Burchard.

Agricultural industry:
- As a soil amendment, c, m,[1]
- As an insecticide, c, m.
- As a fungicide, c, m.

Bleaching industry:
- Manufacture of bleaching powder, "Chloride of lime," c.
- Bleaching and renovating of rags, jute, ramie, and various paper stocks, c, m.

Caustic alkali industry:
- Manufacture of soda, potash and ammonia, c.

Chemical industries:
- Manufacture of ammonia, c.
- Manufacture of calcium carbide, calcium cyanimid and calcium nitrate, c.
- Manufacture of potassium dichromate and sodium dichromate, c.
- Manufacture of fertilizers, c, m.
- Manufacture of magnesia, m.
- Manufacture of acetate of lime, c.
- Manufacture of wood alcohol, c.
- Manufacture of bone ash, c. m.
- Manufacture of calcium carbides, c.
- Manufacture of calcium light pencils, c.
- In refining mercury, c.
- In dehydrating alcohol, c.
- In distillation of wood, c.

Gas manufacture:
- Purification of coal gas and water gas, c. m.

Glass manufacture:
- Most varieties of glass and glazes, c.

Milling industry:
- Clarifying grain, c, m.

Miscellaneous manufactures:
- Rubber, c, m.
- Glue, c, m.
- Pottery and porcelain, c, m...
- Dyeing fabrics, c, m.
- Polishing material c, m.

Oil, fat, and soap manufacture:
- Manufacture of soap, c.
- Manufacture of glycerine, c.
- Manufacture of candles, c.
- Renovating fats, greases, tallow, butter, c, m.
- Removing the acidity of oils and petroleum, c, m.
- Lubricating greases, c, m.

Paint and varnish manufacture:
- Cold-water paint, c, m.
- Refining linseed oil, c. m.
- Manufacture of linoleum, c, m
- Manufacture of varnish, c, m.

Paper industry:
- Soda method, c.
- Sulphite method, m.
- For strawboard, c, m.
- As a filler, c, m.

Preserving industry:
- Preserving eggs, c.

Sanitation:
- As a disinfectant and deodorizer, c.
- Purification of water for cities, c.
- Purification of sewage, c.

Smelting industry:
- Reduction of iron ores, c, m.

Sugar manufacture:
- Beet root, c.
- Molasses, c.

Tanning industry:
- Tanning cowhides, c.
- Tanning goat and kid hides, c, m.

Water softening and purifying, c.

[1] High calcium lime is indicated by "c," magnesian and dolomitic lime by "m."

MINERAL WATERS.

G. C. MATSON.

According to the returns received from spring owners, the mineral-water trade of Alabama continued to prosper during 1910, sales increasing from 116,645 gallons reported during 1909 to 133,159 gallons in 1910, an increase of 16,514 gallons, or a little over 14 per cent. The value, however, owing to a decline of 2 cents per gallon in the average price for the year, increased only 7 per cent, or from $28,595 in 1909 to $30,639 in 1910. There were no new springs reporting during 1910, and one which sold a considerable quantity during 1909 changed ownership during the year and could not furnish data, thus decreasing the total number of springs from 10 to 9. About three-fourths of the total sales of mineral water in Alabama is used medicinally. There are resorts at 6 of the springs, accommodating more than 1,000 people, and the water at 3 is said to be used for bathing purposes. In addition to the quantity reported as sold, there were 10,500 gallons used for the manufacture of soft drinks.

The following list of 9 springs reported sales:

Bailey Springs, Florence, Lauderdale County.
Bromberg Gulf Coast Lithia Springs, Bayou La Batre, Mobile County.
Healing Springs, Healing Springs, Washington County.
Ingram Lithia Wells, near Ohatchee, Calhoun County.
Livingston Mineral Springs, Livingston, Sumter County.
Luverne Mineral Spring, Luverne, Crenshaw County.
MacGregor Springs, Spring Hill, Mobile County.
Magnolia Spring, Magnolia Springs, Baldwin County.
Matchless Mineral Wells, east of Greenville, Butler County.

The following table shows the increase in the value of the mineral waters produced in 1910, over the value of those produced in 1909.

Production of Mineral Waters in 1909 and 1910.

	No. of Springs.	Quantity Sold (gal.)	Average retail price.	Value of Medicinal Waters.	Value of Table Waters.	Total Value of Mineral Waters.	Percentage of Total U. S. Value.
1909	10	116,645	$0.25	$21,208	$7,387	$28,595	0.41%
1910	9	133,159	$0.23	$23,179	$7,460	$30,639	0.48%
Increase	......	16,514	....	$ 1,971	$ 73	$ 2,044	....
Percentage	......	14.15%	....	9.29%	0.99%	7.15%	....

Since 1910 a number of other Mineral waters have been reported and will be taken into account in the statistics of 1911 and following years.

SAND AND GRAVEL.

C. A. ABELE.

The total production of sand and gravel in the State in 1910 was 307,715 short tons, valued at $100,261, as compared with 307,456 short tons, valued at $109,478 in 1909, a net increase in quantity of 259 short tons, or .084 per cent., and a decrease in value of $9,217, or 8.42 per cent.

The following tables give the production, value, and uses of the sand and gravel in 1909 and 1910, and a comparison of these years:

Production and Value of Sand in 1909 and 1910.

	Molding Sand		Building Sand		Engine Sand		Furnace Sand		Other Sand		Total	
	Quantity tons	Value	Quantity tons	Value	Quantity tons	Value	Quantity tons	Value	Quantity tons	Value	Quantity tons	Value
1909	119,999	$57,236	169,567	$49,249	6,510	$1,993	100	$50	1,280	$950	307,456	$109,478
1910	56,085	22,069	228,797	73,567	6,350	1,930	286	148	16,197	2,547	307,715	100,261
Increase or Decrease	—63,914	—35,237	+59,230	+14,318	—160	—.63	+186	+98	+14.917	+1,397	+259	—9,217
Per cent	— 53.26	—61.54	+35.52	+29.08	—2.46	—0.34	+186.0	+196.	+1,173.2	+147.05	+0.084	—8.42

***Production and Value of Sand and Gravel in* 1909 *and* 1910.**

	Gravel		Sand		Total		% of Total U. S. Value
	Quantity tons	Value	Quantity tons	Value	Quantity tons	Value	
1909	314,322	$104,918	307,456	$109,478	621,778	$214,396	1.16%
1910	311,538	87,330	307,715	100,261	619,253	187,591	.89%
Increase or Decrease	—2,774	—17,588	+259	—9,217	—2,525	—26,805	......
Per cent	—0.88	—16.76	+0.084	—8.42	—0.406	—12.5	......

STONE.

E. F. BURCHARD.

The figures presented in the following report have to do with the stone produced and sold by the quarrymen and include only such manufactured product as is put on the market by the quarrymen themselves. This applies especially to rough and dressed building stone, dressed monumental stone, crushed stone, flagstone, curbstone, and paving blocks. The value given to this manufactured product is the price received by the producer, free on board at point of shipment, and includes therefore the cost of labor necessary to dress the stone. The stone reported as sold rough includes stone sold as rough stock to monumental works, and to cut-stone contractors for building purposes; stone sold as riprap, rubble, and flux; and includes the value of only such labor as is required to get the stone out of the quarry in the shape required by the purchaser. The value given to this stone is the price received by the quarryman free on board at point of shipment. In case the stone is sold to local trade the value is given as the quarryman sells the material, generally at the quarry, but in some cases delivered, if this is done by the producer. In some instances a long haul to market or to the railroad in-

creases the cost of the material, and therefore of the selling price.

UNIT OF MEASUREMENT.

Owing to the variety of uses to which stone is put there is no regular unit of measurement employed by the quarrymen, the stone being sold by the cubic yard, the cubic foot, the ton, cord, perch, rod, square foot, square yard, square, etc. Building and monumental stone, especially the dressed product, is usually sold by the cubic foot or the cubic yard, although this unit varies with the class of stone and with the locality: a large quantity of the rough stone is sold by the perch, cord and ton. Rubble and riprap, including stone for heavy masonry, such as breakwater and jetty work, are generally sold by the cord and ton. Fluxing stone and stone for chemical use—as for alkali works, sugar factories, carbonic-acid plants, paper mills, etc.—are sold by the long ton. Flagstone and curbstone are sold by the square yard and the square foot, the thickness being variable and depending on the order received by the quarrymen. Paving blocks are sold invariably by number of blocks, and as such have been tabulated and published for several years; these blocks, however, are not of uniform size, the value depending on the size and amount of labor necessary to cut the block into the shape desired. Crushed stone is reported as sold by the cubic yard or ton, the short ton being more generally used. The weight of a cubic yard varies from 2,300 to 3,000 pounds, the average weight being 2,500 pounds. In certain localities this crushed stone is sold by the "square" of 100 square feet by 1 foot, or 100 cubic feet to a square. It is also of interest to note the selling of crushed stone by the bushel, 21 1-2 bushels reperesenting a cubic yard of about 2,700 pounds. As most of the crushed-stone producers report the quantity according to some unit, it has been possible to convert the crushed stone into short tons, which unit represents the larger number of producers and is the most convenient.

LIMESTONE.

This report does not include the value of the stone burned into lime, nor of that used in the manufacture of Portland cement. The former values are given under the heading, Lime; the latter are included in the value of the cement.

As thus limited the total value of limestone produced in 1910 was $714,516, as compared with $700,642 in 1909, an increase of $13,874.

The values from 1906 to 1910 are given below for comparison.

1906	1907	1908	1909	1910
$579,344	$694,699	$479,730	$700,642	$714,516

The values of limestone produced in 1909 and 1910, classified according to the uses may be seen in the following table:

Values of Limestone Produced in 1909 and 1910.

	1909	1910	Increase or Decrease	Per cent
Rough Building	$ 775	$ 1,901	$ +1,126	+145.29%
Dressed Building	27,197	34,001	+6,804	+ 25.01%
Paving	2,000	4,500	+2,500	+125.00%
Curbing	46,115	....	....	....
Rubble	8,460	....	....	....
Riprap	19,200	37,505	+18,305	+95.34%
Road Making	60,452	64,872	+4,420	+7.24%
Railroad Ballast	5,521	5,842	+321	+5.81%
Concrete	16,825	16,199	—626	—3.72%
Flux	512,585	545,988	+33,403	+6.51%
Other	*1,512	3,708	+2,196	....
Total	$700,642	$714,516	+$13,874	+1.98%
Percentage of total U. S. value	2.18	2.62	....	....

* Includes limestone for agricultural purposes.

LIMESTONE FOR BUILDING PURPOSES.

EUGENE A. SMITH.

From the tables above it will be seen that by far the largest part of the limestone for other purposes than lime burning produced in Alabama 1909-1910, has been for flux rock in the iron furnaces. Crushed stone for road making and riprap follow next, and then dressed building stone.

The preparation of cut stone for building purposes in Alabama, while on the increase, is not yet what it should be. Practically all of this material comes from the quarries in the Subcarboniferous limestone of the Tennessee Valley, the most important quarries being at Rockwood in Franklin County, operated by Foster-Creighton-Gould Co., of Nashville. This stone is quite similar in appearance, composition, and other qualities to the Indiana stone, and so far as experience in the use of the stone from the two localities in the buildings of the University of Alabama goes, the Alabama stone holds its own under influence of the weather better than does the Indiana stone. Stone steps, door sills, and window sills, buttress caps, etc., of the Alabama stone put in place in 1885 show practically no deterioration in color and wear under foot, and in crumbling and roughening under the influence of the weather, which can not be said of some portions of the Indiana stone used in buildings erected in 1909-10. The Rockwood quarries have most modern and approved methods of machinery for sawing the stone and handling it in transit to the mills and elsewhere. The stone is of massive formation, of great thickness and extent. Blocks weighing as much as 25 tons, without crack or flaw, are not infrequently quarried, the size of the blocks being practically limited only by the capacity of the hoisting machinery.

The Oolitic variety is most extensively used for building and monumental work. It is of light gray color, uniform grain, and homogeneous texture. It possesses a quality of cheapness, it can be cut to any design required, and is at the same time strong and durable.

At the present time the business at this quarry is confined to the furnishing of rough and sawed stone to the cut stone contractor or dealer.

With the installing of adequate machinery at the quarry for doing the finished work, there should never be any longer any reason for going outside of the State for this quality of stone. Already the material has been very extensively used in public buildings in Mississippi, Tennessee, as well as in Alabama. The only reason why it was not used in the recently erected buildings at the University of Alabama was that at the time these building contracts were let, the quarries furnished only the rough sawn stone and there was not in Alabama any establishment adequately equipped for the dressing of the stone in the quantity needed.

MARBLE.

EUGENE A. SMITH.

The marble of Alabama is of two kinds, crystalline or true marble and non-crystalline.

The cystalline or statuary marble occurs mainly in a narrow valley along the western border of the metamorphic area, extending from Marble Valley in Coosa County, through Talledega into Calhoun. The outcrops have a width of about a quarter of a mile and a length of 60 miles at least.

The best of these occurrences as yet known are in Talladega County and the principal quarries from which the stone has been obtained are Gantt's and Herd's near Sylacauga, Nix's near Sycamore, and Taylor's and McKenzie's near Taylor's Mill east of Talladega. From all these marble was quarried before the Civil War. The only establishment actually producing marble in 1910 was the Alabama Marble Co. af Gantt's a few miles southwest of Sylacauga. This establishment has a plant with a capacity of something over 200,000 cubic feet per year, and its marble has been used in more than 140 important buildings throughout the United States. The marble

from this place is now well established as a material fully equal if not superior to the imported Italian marbles. It can be seen in the new National Museum in Washington. The mill was destroyed by fire in 1910, but has since been rebuilt on a larger scale.

The Talladega Marble Company with quarries near Taylor's Mill, was idle in 1910, but preparations are in progress for starting up the quarries soon.

Mr. Bishop, near Marble Valley south of Talladega Springs has recently exposed a fine body of marble, and expects soon to begin operations. The Scott Brothers near the old Nix Quarry not far from Sycamore, have also exposed a fine body and have many drill cores proving the superior quality of the marble as well as its very considerable thickness.

A beautiful quality of variegated limestone or marble—red, pink, and white—belonging probably to the Cambrian formation, occurs in Shelby County a mile or two south of Shelby Springs station on the L. & N. railroad, and extending thence southwest for a mile or two. Nothing but prospecting work has been done on this marble. The Trenton limestone in the Appalachian valleys, particularly Jones Valley below Bessemer, contains marble quarried in the vicinity of Knoxville. Also at Pratt's ferry on the Cahaba River in Bibb County a quarry was for many years worked in this formation and turned out a very beautiful quality of marble varying in color from gray through pink, red, and brown shades.

In the Coastal Plain the St. Stephens limestone of the Tertiary holds ledges of hard, almost crystalline rock capable of taking good polish. The colors vary from nearly white, through shades of yellowish into red, and it would make a handsome decorative marble, especially for inside work.

Other limestone formations, such as the Subcarboniferous and the Knox Dolomite, could in places be drawn upon for marble.

SANDSTONE.

The value of the sandstone produced in Alabama from 1906 to 1910 is shown below, the increase in 1910 over 1909 being $31,736.

Value of Sandstone production from 1906 *to* 1910.

1906	1907	1908	1909	1910
$40,467	$48,673	$34,099	$77,327	$109,063

Value and Uses of Sandstone Produced in 1909 *and* 1910.

	Rough Building	Ganister	Rubble	Riprap	Concrete	Other	Total	% of Total Value.
1909	$ 3,951	......	$15,347	$325	$51,432	*$,6272	$77,327	0.96%
1910	100	$12,088	20,802	20,073	56,000	......	109,063	1.37%
Increase or Decrease	—3,851	......	+5,455	+19,748	+4,568	......	+31,736	......
Per cent	—96.2%	......	+35.54%	+607.62%	+8.88	......	+40.78	......

* Includes dressed building stone (one producer.)

FUTURE PROBABLE PRODUCTION.

The following minerals have been produced in Alabama in past years, but no production was reported for 1910; Fullers Earth, Manganese ore, Mica, Ocher, Pyrite. Since all these occur in quantity and of quality to make them of commercial value, the production may be resumed at any time.

Among the probable productions in the near future, are natural gas and petroleum, onyx marble, turquoise and other minerals noticed in the Index to the Mineral Resources of Alabama a publication of the State Geological Survey.

Natural gas under pressure of 630 pounds has been obtained from several wells in Fayette County, and smaller quantities under less pressure have been obtained near Huntsville and elsewhere.

A Report with map on the Fayette County Gas Field has been published by the survey during the past year. No commercial production has yet been reported.

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GEOLOGICAL SURVEY OF ALABAMA

EUGENE ALLEN SMITH, *State Geologist*

BULLETIN No. 13

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1911

COMPILED FROM MINERAL RESOURCES OF THE UNITED STATES

TRANSFERRED TO GEOLOGICAL SCIENCES LIBRARY

By

CHARLES ARTHUR ABELE

UNIVERSITY, ALABAMA
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PRESS
BROWN PRINTING CO.
MONTGOMERY
ALABAMA

LETTER OF TRANSMITTAL.

UNIVERSITY, ALA., March, 1913.

HON. EMMET O'NEAL,
Governor of Alabama,
Montgomery, Ala.

SIR:—I have the honor to transmit herewith the manuscript of a Report on the Mineral Production of Alabama for the year 1911, with the request that it be printed as Bulletin No. 13 of the Geological Survey of Alabama.

Very respectfully,

EUGENE A. SMITH,
State Geologist.

GEOLOGICAL CORPS.

Eugene Allen Smith, Ph. D.________________________State Geologist
William F. Prouty, Ph. D.________________________Chief Assistant
Robert S. Hodges________________________Chemist
Herbert H. Smith________________________Curator of Museum
Roland M. Harper________________________Botanist
George N. Brewer________________________Field Assistant
Charles Arthur Abele________________________
________Clerk in charge of Statistics of Mineral Production
James A. Anderson________________________Clerk in charge of Mailing List
A. T. Donoho________________________Stenographer

RIVER GAGE HEIGHT OBSERVERS.

C. J. Stowe________________________Jackson's Gap, Tallapoosa River
J. E. Whitehead________________________Riverside, Coosa River
George Havens________________________Epes, Tombigbee River
W. G. Early________________________Pera, Pea River
S. T. Dillard________________________Beck, Conecuh River

From the records of daily observations of the gage readings at these places when extended through sufficient time, the calculations of available horsepower to be obtained from the different streams is made.

TABLE OF CONTENTS.

PREFACE.

The statistics of all the minerals included in the following pages have been collected in cooperation with the United States Geological Survey, and have been compiled by Mr. Abele from advance chapters of the *Mineral Resources of the United States,* a publication of the Federal Survey.

The introductory and general matter in each of these articles has either been taken without change from the U. S. advance chapters or has been rearranged or condensed from these chapters, or entirely rewritten to suit it for our present purposes. In each case credit is given to the author.

INTRODUCTION.

THE following article by Mr. E. W. PARKER, of the United States Geological Survey, gives a summary of the Mineral Production of Alabama, and brings out the relation which this State holds to other states in the quantity and value of the mineral products of the Nation. *

As Pittsburgh, Pa., is the "Birmingham" of the western hemisphere, so Birmingham, Ala., is the "Pittsburgh" of the Southern States. The occurrence of the iron ores, coking coals, and limestones in close proximity in the vicinity of Birmingham enables that district to produce iron at less cost than any other region of the world. It has followed, therefore, that in years of depression of the iron trade, as in 1911, the ill-effects are exhibited less in Alabama than in other iron-making sections of the country, while in years of plenty Alabama benefits nearly as much as other States. In 1911, for instance, the total percentage of decrease from 1910 in the production of iron ores for the United States was 27.95, while Alabama's output decreased 17.61 per cent. The value of the iron ores produced in the United States in 1911 was 38.59 per cent less than in 1910; the value of Alabama's ores fell off scarcely half as much in proportion, or 19.85 per cent. In 1910, on the other hand, the total increase in the production of iron ores was 11.21 per cent, and Alabama gained 11.11 per cent, while the percentages of increases in value were, respectively, 27.98 and 21.76. Alabama ranks third among the states in the production of iron ores, and fifth in the manufacture of pig-iron, but it must be remembered that the two States, Minnesota and Michigan, which lead Alabama in the production of iron ores, are relatively unimportant in the manufacture of iron, while three of the States (Pennsylvania, Ohio, and Illinois) which exceed it in the quantity and value of pig-iron produced, obtain their ores from the Lake Superior Region, while New York secures at least half of its ores from the same source. As a producer of iron ores for home con-

*Manufacturers' Record, Feb. 13, 1913.

sumption, and as a manufacturer of pig-iron from its own ores, Alabama stands alone.

As a producer of coal, Alabama ranks fifth among all the States, and second in the Southern group. In the quantity of coke made, Alabama and West Virginia are usually in a neck-and-neck race, West Virginia sometimes leading, as in 1910, and Alabama again taking first place, as in 1911. When the value of coke is considered, however, Alabama takes precedence, for although the West Virginia is of better quality, the home markets give to the Alabama operators a marked advantage in the prices obtained for their output. Coal represented 68 per cent of the total of $28,000,000 worth of mineral products obtained in Alabama in 1911. The value of the iron ores was 17 per cent of the total; the clay working industries added 7 per cent; and the quarry products, principally limestone, lime, and marble, 4.5 per cent. Another 2 per cent is represented by the value of cement produced. Alabama produces a small amount of silver and gold; and other products of minor importance are bauxite, graphite, mica, millstones, mineral waters, natural gas, sand and gravel.

The discrepancy between the above total value and that given in our summary is due to the fact that we have used the value of the pig iron produced, instead of the value of the iron ore mined.—E. A. S.

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1911.

ABRASIVES.

EUGENE A. SMITH.

ALABAMA'S production of abrasives is at present limited to a small number of millstones; but there are several materials in different parts of the state which are sufficiently promising to be worth investigation and thorough testing.

Infusorial or Diatomaceous Earth.—This material is of organic origin, being composed, in part at least, of the siliceous tests or shells of microscopic organisms both animal and vegetable. A diatomaceous earth with considerable admixture of clay and other impurities, occurs abundantly in many localities in the lower part of the State. As, for instance, in the recent swamp deposits near Mobile and in the second bottom deposits of the Alabama River at Montgomery. These are fresh water deposits.

In the Buhrstone and Clayton formations of the Tertiary there are very heavy deposits of diatoms, radiolaria and similar forms of marine origin. The Buhrstone material is a light, somewhat porous substance very high in silica, 86.3 per cent. A somewhat similar material, that is, a light porous substance having much the appearance of flint clay, occurs abundantly at Clayton and other nearby localities in Barbour County.

Polishing powder or Tripoli of very different origin, occurs in many localities in North Alabama. This is a light, porous material known as rotten stone and consisting of finely divided siliceous matter, the result of the thorough leaching of the cherty limestone and dolomite formation of the Lower Silurian and of the Ft. Payne division of the Lower Carboniferous. The Tripoli found in the Knox Dolomite is usually a coherent rock, whilst the sub-Carboniferous material is often a pulverulent substance of pure white color like flour. Both these forms of Tripoli are essentially pure silica or with very slight ad-

mixture of clay. The solid masses need to be crushed, ground and bolted preparatory to using, while the pulverulent form would probably require no manipulation beyond passing through a fine mesh sieve or bolting.

The Knox Dolomite tripoli is most abundant in the Coosa Valley region, especially Calhoun and Talladega counties, while the pulverulent and other material of the Sub-carboniferous is most abundant in the Tennessee Valley, in Lauderdale and Limestone Counties.

A specimen of very white fine powder of 99.4 per cent silica has recently been received from Geneva County. If this deposit should be found of sufficient thickness and easy of access, it should find a market.

BAUXITE.

W. C. PHALEN.

USES.

THE chief uses of bauxite were outlined in this report for 1910, as follows: (1) As raw material in the production of metallic aluminum; (2) in the manufacture of aluminum salts; (3) in the manufacture of bauxite bricks; (4) in the manufacture of alundum (fused alumina) for use as an abrasive. The use of bauxite in the manufacture of calcium aluminate to give a quick set to plaster compositions should be added, as well as the extended use which alundun is finding in the refractory industries. The two latter uses are described in detail farther on.

1. The use of bauxite in the production of metallic aluminum is by far the most important of those enumerated above. A large part of the entire output of Arkansas is used in the metallic aluminum industry, and the figures of production from this State have shown phenomenal growth during recent years. A large part of the French product is also used in the manufacture of metallic aluminum.

2. Only the purer bauxite is used in the manufacture of chemicals, such as alum, aluminum sulphate, and aluminum salts in general. Freedom from oxide of iron is essential in the material to be used in the chemical manufactures.

3. The use of bauxite in the manufacture of refractory brick has by no means reached a perfected stage, but it is understood that several manufacturers are now experimenting on processes in which it is admixed with other materials. The life of bauxite-brick linings is as yet undetermined, though it is known to exceed by far the life of silica brick or fire-clay brick. The high cost of raw material, as well as that of its manufacture, makes the ultimate cost of bauxite brick excessive as compared with that of the other two bricks mentioned.

4. Bauxite is used on a large scale in the manufacture of the artificial abrasive, alundun, at Niagara Falls. This abra-

sive is made in the electric furnace by fusing calcined bauxite. It is high in crystalline aluminum oxide, and virtually amounts to a form of artificial corundum. Its quality is under complete control, and hence it can be duplicated with ease in the various abrasive products, a factor of great importance in any successful abrasive industry. Alundum is particularly efficient in the grinding of steel.

New use for alundum.—L. E. Saunders, of the Norton Co., of Niagara Falls, has recently presented data on the value of alundum (electrically fused alumina) as a refractory. Alundum was primarily developed as an abrasive, but its resistance to heat and its other valuable qualities have led to its introduction into the field of the refractories. * * *

Use of bauxite in calcium aluminate.—Henry S. Spackman and E. W. Lazell have taken out a series of patents (Nos. 903017-903020, dated November 3, 1908) on cementitious material and its preparation, in which use is made of the mineral bauxite. The inventions relate more particularly to the preparation of plaster compositions by the incorporation in them of hydraulic calcium aluminate to give them a quick set. Hydraulic calcium aluminate compounds may be prepared by mixing in proper proportions finely ground lime and bauxite or other alumina compounds, such as kaolin or high alumina clays, high alumina slag, etc. Such mixtures may be rendered hydraulic and given a quick initial set when dried, ground, and mixed with water by calcining and sintering them. If desired, the temperature may be carried higher, so as to effect fusion.

PRODUCTION.

The following table gives the production and value of bauxite from 1889 to 1911, inclusive:

Production of bauxite in the United States, 1889-1911, by States, in long tons.

Year	Georgia	Alabama	Arkansas	Total	Value
1889	728	----------	----------	728	$2,366
1890	1,844	----------	----------	1,844	6,012
1891	3,301	292	----------	3,593	11,675
1892	5,110	5,408	----------	10,518	34,183
1893	2,415	6,764	----------	9,179	29,507
1894	2,050	9,016	----------	11,066	35,818
1895	3,756	13,313	----------	17,069	44,000
1896	7,313	11,051	----------	18,364	47,338
1897	7,507	13,083	----------	20,590	57,652
1898	----------	----------	----------	25,149	75,437
1899	15,736	14,499	5,045	35,280	125,598
1900	19,739		3,445	23,184	89,676
1901	18,038		867	18,905	79,914
1902	22,677		4,645	27,322	120,366
1903	22,374		25,713	48,087	171,306
1904	21,913		25,748	47,661	235,704
1905	15,173		32,956	48,129	240,292
1906	25,065		50,267	75,332	368,311
1907	----------	----------	----------	*97,776	480,330
1908	14,464		*37,703	52,167	263,968
1909	22,227		*106,874	129,101	679,447
1910	33,096		*115,836	148,932	716,258
1911	30,170		*125,448	155,618	750,649

*Production of Tennessee included.

Production of Bauxite in 1910 and 1911.

	Quantity Tons	Value	Percentage of Total U. S. Production	Percentage of Total U. S. Value
1910	9,517	$38,068	6.39	5.31
1911	8,848	35,392	5.68	4.71
Decrease	669	2,676	----------	----------
Per cent	7.03	7.03	----------	----------

CEMENT.

EUGENE A. SMITH.

Puzzolan or Slag Cement.

DURING the past four years only one establishment in Alabama has been engaged in the manufacture of slag cement, using the material from the furnaces about Birmingham. The production is included in the returns for Portland cement and cannot be given separately.

Portland Cement.

Alabama contains large supplies of limestone, chalk, clay and shale well adapted for Portland Cement manufacture, and widely distributed throughout the state. Coal and labor are abundant and cheap, transportation facilities are excellent, and many of the best limestone and chalk localities are situated on navigable rivers, giving ready access and cheap water transportation to Galveston, New Orleans, Mobile, Charleston, and other ports of the Gulf and Atlantic Coasts. This advantage of location will be immensely increased with the opening of the Panama Canal for cement plants located in Alabama will be more than a thousand miles nearer to the Isthmus than their nearest possible competitors.

The limestones and shales of the northern part of the state lie so close to each other, and above all so close to the great coal mines which must supply the fuel, that the establishment of Portland Cement plants near the coal mines would give to this industry in Alabama the same advantages which the proximity of the iron ore, the coal, and the stone has given to the iron industry, and which has placed our state beyond competition.

As a Portland cement mixture, ready for burning, consists approximately of 75 per cent. lime carbonate and 25 per cent. of clayey matter, the material furnishing the lime carbonate is necessarily of more economic importance than that from which the silica and alumina are derived. In consequence, a

Portland cement plant is usually located in the immediate vicinity of a suitable limestone, while the clay or shale required to complete the mixture may be brought some distance.

The limestones formations in North Alabama which can supply the stone adapted for use in cement manufacture are the Trenton or Pelham limestone and the Bangor or Subcarboniferous. In close proximity to both these limestone formations are the shales of the Clinton, Subcarboniferous and Coal Measures.

At the present time there are two cement plants in North Alabama, namely, the Standard Portland Cement Co., located at Leeds in Jefferson County, and the Atlantic & Gulf Portland Cement Co., located at Ragland in St. Clair County. Both of these plants make use of the hard Trenton limestone, and the Standard Cement Co., according to Burchard of the U. S. Geological Survey, uses the shale of the Clinton formation whilst the Ragland Company makes use of the shales of the Coal Measures. Up to the present time no establishment is utilizing the Bangor limestone.

In Middle Alabama the soft, chalky Cretaceous limestone of the Selma Chalk, is the material utilized by the Alabama Portland Cement Co., at Spocari, near Demopolis. The same Company makes use of residual clays overlying and derived from the weathering of the Selma Chalk. During 1911 there was no production reported from the Demopolis plant.

In Southern Alabama the St. Stephens limestone outcropping east and west across the state, furnishes excellent material for Portland Cement manufacture, using either residual clays from decomposition of the limestone, or the clays of the Grand Gulf formation which are almost everywhere in close proximity to the limestone. The Mobile Cement Co. has been for some time engaged in the building of a plant at St. Stephens, but no production has yet been reported.

The following table contains the leading facts relative to the puzzolan-cement industry for the five years 1907 to 1911, inclusive:

Statistics of the puzzolan-cement industry, 1907-1911, by States.

	1907	1908	1909	1910	1911
No. of plants reporting production:					
Alabama	1	1	1	1	1
Illinois	1	-------	-------	-------	-------
Kentucky	1	-------	-------	-------	-------
Maryland	-------	-------	-------	-------	-------
New Jersey	-------	-------	-------	-------	-------
New York*	1	-------	-------	-------	1
Ohio	2	2	2	2	1
Pennsylvania	1	1	1	1	1
Total	7	4	4	4	4
Production in barrels	557,252	151,451	160,646	95,951	93,230
Value of production	$448,998	$95,468	$99,453	$63,286	$77,786

*Includes production of Collos cement in 1911.

Production and Value of Cment (Including Puzzolan and Portland) in Alabama in 1910 and 1911.

	No. of Producers	Quantity (bbls.)	Value	Percentage of total U. S. value
1910	3	406,214	$387,600	0.56
1911	3	593,911	529,359	0.79
Increase	------------	187,697	141,759	-----------
Percentage increase	------------	46.23	36.57	-----------

CLAY AND CLAY PRODUCTS.

JEFFERSON MIDDLETON AND C. A. ABELE.

CLAY.

CLAY available for the manufacture of clay products is one of the most widely spread of our minerals. Clay miners are usually also the manufacturers of the lower-grade clays, but as the higher grades of ware are reached, the rule is that fewer and fewer manufacturers are also miners, until in the highest grades of ware the rule is that the manufacturer is not the miner of the clays that he uses. The figures given in the following tables represent clay that is mined and not manufactured by the miner, but is sold as clay. The clay thus sold is small in quantity compared with that consumed and includes mainly clay used for refractory products.

The total quantity of clay mined in Alabama, and sold as such in 1911 was 35,203 short tons, as compared with 75,082 short tons in 1910, a decrease of 39,879 short tons, or 53.11 per cent. The value of the clay mined in 1911 was $29,909, a decrease from 1910 of $8,134, or 21.38 per cent. Fire clay was the only kind of raw clay produced in the state in 1911, and even this was 19,279 short tons short of the 1910 production, which was 54,482 short tons. The decrease in the value of the fire clay was $2,484, or 7.66 per cent.

Quantity and Value of Clay Produced in 1911.

Kind	Quantity Produced Short Tons	Value	Aver'g. Value per ton	Percentage of Total U. S. value
Fire Clay	35,203	$29,909	$0.821	0.859

No other variety of clay was produced.

Comparison of Clay Production in 1910 and 1911.

	Fire Clay		Miscellan. Clay		Total	
	Quantity Short Tons	Value	Quantity Short Tons	Value	Quantity Short Tons	Value
1910	54,482	$32,895	20,600	$5,650	75,082	$38,045
1911	35,203	29,909	-------	-------	35,203	29,909
Decrease	19,279	2,484	-------	-------	39,879	8,134
Per cent	35.38	7.66	-------	-------	53.11	21.38

No production of Miscellaneous Clay in 1911.

CLAY-WORKING INDUSTRIES.

The total value of the clay products in 1911 was $1,947,102, an increase over 1910 of $279,543, or 16.76 per cent. The value of the brick and tile and fire-proof products was $1,918,-606, or 98.53 per cent of the total.

By the above increase in value, Alabama rose in rank from 22nd in 1910, to 17th in 1911. In the production of Brick and Tile alone, the State rose in rank from 19th in 1910, to 17th, in 1911. And by an increase of $6250 in the value of Pottery produced the State increased its rank, as in Brick and Tile, from 19th in 1910, to 17th in 1911.

Value of Brick and Tile, and Potteries, 1907-1911.

Product	1907	1908	1909	1910	1911
Brick:					
Common—					
Quantity	159,316,000	120,237,000	146,180,000	135,785,000	129,694,000
Value	$1,004,644	$690,963	$799,693	$746,961	$708,903
Average per M.	$6.31	$5.75	$5.47	$5.50	$5.47
Vitrified—					
Quantity	13,362,000	18,248,000	20,444,000	19,772,000	21,444,000
Value	$183,895	$244,084	$262,376	$236,516	$246,707
Average per M.	$13.76	$13.38	$12.83	$11.96	$11.51
Front—					
Quantity	(a)	(a)	(a)	(a)	9,169,000
Value	(a)	a()	(a)	(a)	$128,403
Average per M.	$13.90	$17.89	$16.19	$15.96	$14.00
Fancy value	(a)	(a)	(a)	---------	(a)
Fire "	$170,711	$122,354	$196,887	$163,672	$193,375
Draintile "	(a)	$2,046	(a)	$3,773	$3,777
Sewer pipe "	(a)	(a)	(a)	(a)	(a)
Fireproofing "	(a)	(a)	(a)	(a)	(a)
Pottery:					
Red earthenware "	$7,530	$15,058	$11,886	$8,475	$11,248
Stoneware and yellow and Rockingham ware value	$20,215	$9,031	$24,458	$16,371	$14,758
Miscellaneous "	$367,414	$476,070	$404,832	$496,791	$639,941
Total value	$1,754,409	$1,559,606	$1,700,127	$1,667,559	$1,947,162
Number of operating firms reporting	100	103	100	87	82
Rank of State	20	19	22	22	17

BRICK AND TILE.

The total number of common brick produced in 1911 was 129,694 thousand (M), a decrease from 1910 of 6,091 thousand, or 4.48 per cent. The value was $708,903, a decrease of $38,058 or 5.09 per cent. The value of vitrified brick produced in 1911 was $246,707, an increase over 1910 of $10,191, or 4,31 per cent. Common brick was the only brick and tile product whose production fell off in 1911. Vitrified brick, front brick, fire brick, drain tile, and miscellaneous ware all show an increase ranging from 0.10 to 28.9 per cent. Below is a table showing the production and values for 1911, and one showing the relation of the quantities produced, and the values, in 1911 to those of 1910.

The decrease in the common-brick output may be partly accounted for by the increased use of hollow block or tile for the construction of large buildings and even of dwelling houses. This form of construction offers many advantages, among which are economy in construction, the ease and rapidity with which it can be put in the wall, and its nonconductivity. All of these should be factors in the extension of its use. Structures made of hollow tile may be faced either with brick, stucco, or other material. It seems, therefore, likely that the production of common brick will not show rapid increase in the future, and it is probable that the use of hollow tile or block will largely increase.

Production of Brick and Tile in 1911.

Kind	Quantity M.	Value	Averag. Value per M.	Percentage of Total Alabama Brick & Tile	Percentage of Total U. S. Value
Common Brick	129,694	$ 708,903	$5.47	36.95	1.42
Vitrified Brick	21,444	246,707	11.50	12.86	2.46
Front Brick	9,169	128,403	14.00	6.69	1.48
Fire Brick	11,929	193,375	16.21	10.08	1.33
Drain Tile	------	3,777	------------	.20	0.04
Miscellaneous	------	*637,441	------------	33.22	2.69
Total	------	$1,918,606	------------	100.00	1.50

*Includes also Fancy Brick, Sewer Pipe, Fireproofing, and Silica Brick.

Production of Brick and Tile in 1910 and 1911.

	1910			1911				
	Quantity M.	Value	Averag. Price	Quantity M.	Value	Averag. Price	Increase or Decrease in Value	Per Cent.
Common Brick	135,785	$ 746,961	$5.50	129,694	$ 708,903	$5.47	—$38,058	— 5.09
Vitrified Brick	19,772	236,516	11.96	21,444	246,707	11.50	+ 10,191	+ 4.31
Front Brick	†	†	----	9,169	128,403	14.00	+ 4	------
Fire Brick	10,365	163,672	15.75	11,929	193,375	16.21	+ 29,703	+18.14
Drain Tile	------	3,773	----	------	3,777	----	+ 4	+ .10
Miscellaneous	------	494,391	----	------	*637,441	----	+143,050	+28.9
Total	------	$1,645,313	----	------	$1,918,606	----	+273,293	+16.6

*Includes Fancy Brick, Sewer Pipe, Fireproofing and Silica Brick.
†Included in Miscellaneous.

POTTERIES.

Alabama produces pottery of only the commoner or coarser types, red and yellow earthenware, and most of this is produced for local trade only. The product of the 18 active producing firms was valued at $28,496, an increase over 1910, of $6,250, or 28.09 per cent. Below are tables showing the values of the various kinds of the pottery produced in 1911, and also one giving a comparison of the values in 1910 and 1911.

Value of Pottery Products in 1911.

Kind	Value	Percentage of total Alabama Potteries	Percentage of total U. S. value
Red Earthenware	$11,243	39.45+	1.26
Stoneware and Yellow and Rockingham ware	*17,253	60.54+	2.91
Total	$28,496	100.00	0.08

*Includes miscellaneous ware.

Comparison of Pottery in 1910 and 1911.

Kind	1910	1911	Increase or Decrease	Percentage Increase or Decrease
Red Earthenware	$3,475	$11,243	+$7,768	+223.54
Stoneware and Yellow and Rockingham ware	*18,771	*17,253	— 1,518	— 8.07
Total	$22,246	$28,496	+$6,250	+ 28.09

*Includes miscellaneous ware.

COAL.

E. W. PARKER.

Production.

TOTAL production in 1911, 15,021,421 short tons; spot value, $19,079,949. From the depressed condition of the iron industry in 1911, it was estimated, in a preliminary review published in the closing week of the year, that the coal production of Alabama had decreased about 10 per cent from the high record of 16,111,462 short tons made in 1910. The quantity of coal made into coke, which is immediately affected by the demands of the iron furnaces, did show the marked decrease of 1,288,111 short tons, or 29 per cent, from 4,417,443 tons in 1910 to 3,129,332 tons in 1911. This decrease was in part made up, however, by an increase of approximately 200,000 tons in the production for other purposes and the total decrease amounted to 1,090,041 short tons, or 6.8 per cent. The decrease in value, somewhat less in proportion, was $1,156,904, or 5.7 per cent, from 20,236,853 to $19,079,949. The average price per ton advanced from $1.26 in 1910 to $1.27 in 1911.

Rank of first ten coal-producing States in 1910 and 1911, with quantity and value of product and percentage of each.

1910.

Production				Value			
Rank	State or Territory	Quantity (short tons).	Percentage of total product'n	Rank	State or Territory	Value	Percentage of total value
1	Pennsylvania:			1	Pennsylvania:		
	Anthracite	84,485,236	16.8		Anthracite	$160,275,302	25.5
	Bituminous	150,521,526	30.0		Bituminous	153,029,510	24.3
2	West Virginia	61,671,019	12.3	2	West Virginia	56,665,061	9.0
3	Illinois	45,900,246	9.1	3	Illinois	52,405,897	8.3
4	Ohio	34,209,668	6.8	4	Ohio	35,932,288	5.7
5	Indiana	18,389,815	3.7	5	Indiana	20,813,659	3.3
6	Alabama	16,111,462	3.2	6	Alabama	20,236,853	3.2
7	Kentucky	14,623,819	2.9	7	Colorado	17,026,934	2.7
8	Colorado	11,973,736	2.4	8	Kentucky	14,405,887	2.3
9	Iowa	7,928,120	1.6	9	Iowa	13,903,913	2.2
10	Wyoming	7,533,088	1.5	10	Wyoming	11 706,187	1.9

1911.

Production				Value			
Rank	State or Territory	Quantity (short tons).	Percentage of total product'n	Rank	State or Territory	Value	Percentage of total value
1	Pennsylvania:			1	Pennsylvania:		
	Anthracite	90,464,067	18.2		Anthracite	$175,189,392	28.0
	Bituminous	144,754,163	29.2		Bituminous	146,347,858	23.4
2	West Virginia	59,831,580	12.1	2	Illinois	59,519,478	9.5
3	Illinois	53,679,118	10.8	3	West Virginia	53,670,515	8.6
4	Ohio	30,759,986	6.2	4	Ohio	31,810,123	5.1
5	Alabama	15,021,421	3.0	5	Alabama	19,079,949	3.0
6	Indiana	14,201,355	2.9	6	Indiana	15,326,808	2.4
7	Kentucky	13,706,839	2.8	7	Colorado	14,747,764	2.4
8	Colorado	10,157,383	2.0	8	Kentucky	13,617,217	2.2
9	Iowa	7,331,648	1.5	9	Iowa	12,663,507	2.0
10	Virginia	6,864,667	1.4	10	Wyoming	10,508,863	1.7

Coal production of Alabama in 1910 and 1911, by counties, in short tons.

1910.

County	Loaded at mines for shipment	Sold to local trade and used by employees	Used at mines for steam and heat	Made into coke	Total quantity	Total value	Average price per ton	Average number of days active	Average number of employees
Bibb	1,462,720	6,961	110,883	--------	1,580,564	$2,370,919	$1.50	261	2,666
Etowah	169,251	1,538	1,676	--------	172,465	254,798	1.48	251	388
Jefferson	4,289,536	109,377	329,777	3,570,012	8,298,702	10,247,456	1.23	255	10,832
St. Clair	411,247	2,398	14,764	--------	428,409	571,675	1.33	234	524
Shelby	450,324	3,381	34,436	--------	488,141	780,887	1.60	253	847
Tuscaloosa	412,144	6,842	54,498	607,735	1,081,219	1,232,495	1.14	264	1,496
Walker	3,395,104	66,561	87,118	239,696	3,788,479	4,395,910	1.16	227	4,889
Winston	16,192	250	------	--------	16,442	25,370	1.54	156	57
Other counties*	237,293	8,583	10,855	--------	256,731	356,723	1.39	241	531
Small mines	--------	310	------	--------	310	620	2.00	----	-----
Total	10,843,811	206,201	644,007	4,417,443	16,111,462	$20,236,853	$1.26	249	22,230

1911.

County	Loaded at mines for shipment	Sold to local trade and used by employees	Used at mines for steam and heat	Made into coke	Total quantity	Total value	Average price per ton	Average number of days active	Average number of employees
Bibb	1,515,976	9,592	107,629	--------	1,633,197	$ 2,407.918	$1.47	239	2,631
Blount	80,266	1,900	100	--------	82,266	98,599	1.20	225	189
Etowah	252,866	720	2,274	--------	255,860	360,307	1.40	189	492
Jefferson	4,804,221	86,017	307,265	2,578,887	7,776,390	9,668,726	1.24	246	10,665
St. Clair	509,120	1,584	18,507	--------	529,211	673,576	1.27	240	682
Shelby	430,505	2,723	29,861	--------	463,089	757,772	1.64	240	866
Tuscaloosa	585,666	9,310	61,624	375,058	1,031,658	1,288,235	1.25	265	1,445
Walker	2,820,521	25,077	82,610	175,387	3,103,595	3,598,720	1.16	180	5,360
Winston	16,074	350	------	--------	16,424	25,185	1.50	67	129
Other counties† & small mines	120,348	3,918	5,465	--------	129,731	200,911	1.55	170	248
Total	11,135,563	141,191	615,335	3,129,332	15,021,421	$19,079,949	$1.27	227	22,707

*Blount, Cullman, DeKalb, Jackson and Marion.
†Cullman, DeKalb, Jackson and Marion.

In the following table is presented a statement of the production of coal in Alabama, by counties, during the last five years, with increases and decreases in 1911 as compared with 1910:

Coal production of Alabama, 1907-1911, by counties, in short tons.

County	1907	1908	1909	1910	1911	Increase (+) or decrease (−), 1911.
Bibb	1,297,158	1,166,548	1,338,243	1,580,564	1,633,197	+ 52,633
Blount } Cullman	*336,308	*181,062	*186,261	*235,456	*210,070	− 25,386
Etowah	205,015	8,880	46,194	172,465	255,860	+ 83,395
Jefferson	7,526,275	5,914,129	7,176,922	8,298,702	7,776,390	− 522,312
St. Clair	283,806	193,434	354,005	428,409	529,211	+ 100,802
Shelby	245,087	407,547	524,925	488,141	463,089	− 25,052
Tuscaloosa	1,047,364	712,101	1,006,989	1,081,219	1,031,658	− 49,561
Walker	3,254,919	2,941,836	2,973,776	3,788,479	3,103,595	− 684,884
Winston	35,333	28,408	32,278	16,442	16,424	− 18
Other counties and small mines	19,189	50,648	63,857	21,585	1,927	− 19,658
Total	14,250,454	11,604,593	13,703,450	16,111,462	15,021,421	− 1,090,041
Total value	$18,405,468	$14,647,891	$16,306,236	$20,236,853	$19,079,949	−$1,156,904

*Includes production of Marion County.

So far as known, the earliest record of the existence of coal in Alabama was made in 1834. The first statement of production in the State is contained in the United States census report for 1840, in which year the production is given as 946 tons. The census report for 1850 does not mention any coal production for the State, and the next authentic record is contained in the census statistics of 1860, when Alabama is credited with an output of 10,200 short tons. The mines of Alabama were probably worked to a considerable extent during the Civil War, but there are no records of the actual production until 1870, for which year the United States census reports a production of 11,000 tons. Ten years later the production had increased to 323,972 short tons, but the development of the present great industry really began in 1881 and 1882, when attention was directed to the large iron deposits

near the city of Birmingham, and thus the great "boom" of that city and vicinity was inaugurated. By 1885 the coal production of the State had increased to nearly 2,500,000 tons. Then followed a period of relapse and liquidation, which lasted two years, after which business settled down to a conservative and rational basis and has since developed steadily. In 1902 the coal production of the State reached a total of more than 10,000,000 tons, and reached the maximum of 16,111,462 tons in 1910.

The statistics of production in Alabama from 1840 to the close of 1911 are shown in the following table:

Production of coal in Alabama from 1840 to 1911, in short tons.

Year	Quantity	Year	Quantity	Year	Quantity	Year	Quantity
1840	946	1859	9,000	1878	224,000	1897	5,893,770
1841	1,000	1860	10,200	1879	280,000	1898	6,535,283
1842	1,000	1861	10,000	1880	323,972	1899	7,593,416
1843	1,200	1862	12,500	1881	420,000	1900	8,394,275
1844	1,200	1863	15,000	1882	896,000	1901	9,099,052
1845	1,500	1864	15,000	1883	1,568,000	1902	10,354,570
1846	1,500	1865	12,000	1884	2,240,000	1903	11,654,324
1847	2,000	1866	12,000	1885	2,492,000	1904	11,262,046
1848	2,000	1867	10,000	1886	1,800,000	1905	11,866,069
1849	2,500	1868	10,000	1887	1,950,000	1906	13,107,963
1850	2,500	1869	10,000	1888	2,900,000	1907	14,250,454
1851	3,000	1870	11,000	1889	3,572,983	1908	11,604,593
1852	3,000	1871	15,000	1890	4,090,409	1909	13,703,450
1853	4,000	1872	16,800	1891	4,759,781	1910	16,111,462
1854	4,500	1873	44,800	1892	5,529,312	1911	15,021,421
1855	6,000	1874	50,400	1893	5,136,935		
1856	6,800	1875	67,200	1894	4,397,178	Total	221,175,236
1857	8,000	1876	112,000	1895	5,698,775		
1858	8,500	1877	196,000	1896	5,748,697		

The number of men employed in the coal mines of Alabama in 1911 was 22,707, who worked an average of 227 days, against 22,230 men, for an average of 249 days in 1910. The more working days in 1910 and the larger production in that year were due to the strike in Illinois and other Western States, and to low water in Ohio and Kanawha rivers, which reduced shipments from Pennsylvania and West Virginia to Mississippi River points. The average production per man

in 1911 was 662 tons against 725 tons in 1910. The average daily production per man was 2.92 tons in 1910 and 3 tons in 1911. Most of the Alabama mines are worked 10 hours a day.

Average production per man compared with hours worked per day, and average number of days worked in 1910 and 1911.

Year	8 hours		9 hours		10 hours		All oth'rs	Total	Days Worked	Average Tonnage	
	Mines	Men	Mines	Men	Mines	Men	Men	Men		Per Year	Per Day
1910	18	766	36	2,633	134	17,306	1,525	22,230	249	725	2.91
1911	15	550	50	5,345	102	12,628	4,184	22,707	227	662	2.92

As in 1910, the coal mines of Alabama in 1911 were practically free from labor troubles, there having been only one instance of disaffection reported. In that case 210 men were idle six days. The supply of labor was adequate, and there was no complaint on account of the lack of transportation facilities.

Statistics of Labor Troubles in 1910 and 1911.

Year	Number of Men on Strike	Percentage of total men working	Total days lost	Average number of days lost per man
1910	25	0.11	1,250	50
1911	210	0.92	1,260	6

The returns for 1911 show a decrease of 45 in the number of machines employed, 317 having been reported in 1910 and 272 in 1911.

The production by machines decreased from 2,980,122 tons to 2,936,512 tons. The percentage of the machine-mined product to the total increased, however, from 18.5 in 1910 to 19.6 in 1911. In explanation of the decrease in the number of machines employed in 1911 in the coal mines of Alabama and in the quantity of coal mined by their use, there were 3 mines which reported a total of 27 machines in 1910, which were

idle throughout the whole of 1911. Two other properties at which 7 machines were used in 1910 reported no machines used in 1911. One mine which reported 12 pick machines in 1910 used 2 continuous cutters in 1911, and another, which reported 16 machines in 1910, used but 13 in 1911.

Number and kinds of machines in use, and average production per man compared with production by machines, by short tons, in 1910 and 1911.

Year	Pick	Chain Breast	Long-wall	Short-wall	Total	Average Tonnage: Per year	Average Tonnage: Per day	Production by Machines: Total tonnage by machines	Production by Machines: % of machined coal to state total
1910	215	82	20	----	317	725	2.91	2,980,122	18.50
1911	184	53	13	22	272	6.62	2.92	2,936,512	19.55
Increase or decr.	− 31	− 29	− 7	----	− 45	− 58	+ .01	− 93,610	
Per cent	−14.41	−35.36	−35.00	----	−14.19	−7.31	-----	− 1.46	------

The methods used in the mining of coal were reported by mines having a total production in 1911 of 14,233,483 tons, of which 4,673,719 tons were mined by hand, 2,936,512 tons were mined by machines, and 6,623,252 tons were shot from the solid. The mined coal (that is, the coal undercut by machines, added to that mined by hand) represented 53.5 per cent. of the total, and that shot from the solid, 46.5 per cent. Exclusive of the coal mined by machinery, the percentage of coal shot from the solid was 58.6 and that mined by hand was 41.4 per cent.

Quantity and percentage of bituminous coal produced by different methods in 1911.

Mined by hand	Percentage	Shot off the solid	Percentage	Mined by machines	Percentage	Not reported	Percentage	Total production
4,673,719	31.1	6,623,252	44.1	2,936,512	19.6	787,938	5.2	15,021,421

The quantity of Alabama coal washed in 1911, most of which was used in the manufacture of coke, was 6,251,828 short tons, yielding 5,538,401 tons of cleaned coal and 713,427 tons of refuse.

Quantity and percentage of coal washed, by short tons, in 1910 and 1911.

Year	Quantity of coal washed	Percentage of coal mined	Quantity of clean coal	Refuse	
				Quantity	% of total coal washed
1910	6,772,860	42.03	5,971,305	801,555	11.82
1911	6,251,828	41.61	5,538,401	713,427	11.41
Increase or decrease	— 521,032		— 432,904	— 88,128	
Per cent	7.69		7.09	10.99	

According to statistics compiled by the United States Bureau of Mines there were more men killed by explosions, including those from windy shots, in the coal mines of Alabama in 1911 than in any other State, the death roll from this cause in Alabama totaling 130, or more than 30 per cent of all the deaths from this cause. The total number of men killed underground was 204, there being in addition to the 130 deaths from explosion, 47 from falls of roof or coal, 14 from haulage accidents, 5 from explosions of powder, and 8 from other causes. One man was killed by shaft accident and 4 were killed on the surface. The aggregate deaths from accidents above and below ground were 209. The death rate per 1,000 employees was 9.2 and the number of tons mined for each life lost was 71,873.

For a condensed account of the Coal Fields of Alabama, refer to Bulletin 12 of the Geological Survey of Alabama, Statistics of the Mineral Production of Alabama for 1910.

COKE.

E. W. PARKER.

NOTWITHSTANDING the decrease of 487,506 short tons in Alabama's output of coke in 1911 as compared with 1910, the State once more took second place among the coke-producing States, displacing West Virginia, which had held it for six consecutive years. Prior to 1906 the two States were close rivals for that distinction, which alternated almost regularly between them.

Rank of the first five States in production of coke, 1907-1911.

State	1907	1908	1909	1910	1911
Pennsylvania	1	1	1	1	1
Alabama	3	3	3	3	2
West Virginia	2	2	2	2	3
Illinois	10	9	5	4	4
Colorado	5	5	6	6	5

On account of Alabama's remarkable resources in iron ore, limestone, and coal, and her ability to produce pig iron more cheaply than it can be made anywhere else in the world, the State assumes relatively greater importance in years of depression in the iron trade than when demand is brisk and prices high. The former condition obtained in 1911, and although Alabama's production was less than in 1910, the decrease in iron production and in the manufacture of coke was not so great as in some of the other States. West Virginia, whose coke product has no local outlet, but is sent out of the State to market where it has to compete with cokes from other States, showed a decrease in coke output in 1911 amounting to 1,512,801 short tons, and reducing the total of the State to 2,291,049 tons. The production of Alabama decreased from 3,249,027 tons in 1910 to 2,761,521 in 1911, a loss of 487,506 tons, but exceeding the output of West Virginia by a little over 470,000 tons. The value of Alabama's coke production in 1911 was $7,593,594, against $9,165,821 in 1910, a decrease of $1,572,227, or 17.2 per cent.

Comparison of Production and Value of Coke in Alabama in 1910 and 1911.

	No. of Ovens	Coal Charged Short Tons	Coke Produced Short Tons	Total value of coke at ovens	Per cent of total U. S. value
1910	10,132	5,272,322	3,249,027	$9,165,821	9.19
1911	10,121	4,411,298	2,761,521	7,593,594	9.02
Decrease	11	861,024	487,506	1,572,227	
Per cent		16.33	15.00	17.15	

The average price per ton declined from $2.82 to $2.75. The average price for West Virginia coke in 1911 was $1.85 per ton.

Still another comparison may be made between Alabama's coke production and that of West Virginia. It is well known that the average quality of West Virginia's coal exceeds that of Alabama, yet in 1911 the yield of coal in coke in Alabama's operations was 62.6 per cent and in West Virginia 60.4. A part of this difference is undoubtedly due to the fact that in Alabama 340 by-product ovens were in operation in 1911, from which the output amounted to 669,433 short tons of coke, or 24.24 per cent of the total output of the State. In West Virginia there were 120 retort ovens in operation in 1911 and their output was 165,099 short tons of coke, or 7.21 per cent of the total product. The 340 retort ovens in Alabama consisted of 240 Semet-Solvay ovens at Ensley and 40 at Tuscaloosa, which have been in operation for several years and 60 Koppers ovens, completed during 1911 by the Woodward Iron Co., at Woodward. An additional plant of 280 Koppers ovens was under construction at the close of 1911 at Corey for the Tennesee Coal, Iron & Railroad Co. This was the only new construction work in progress at the end of the year. There were 44 establishments in Alabama in 1911—an increase of 1 over 1910. The number of ovens in existence at the close of 1911 was 10,121, a decrease of 11 as compared with 1910, for whereas 60 retort ovens were added to the equipment in 1911, 71 beehive ovens were abandoned. Of the 44 establishments in Alabama in 1911, 14, with a total of 2,474 ovens, were idle throughout the year. In addition to these there

were 330 ovens, portions of other establishments, which were idle during the entire year. The number of active ovens was therefore 7,317, and the average production from them in 1911 was 377 short tons, against 9,614 active ovens in 1910, with an average production per oven of 338 tons.

The principal coal beds of Alabama which furnish the coal for coke making are the Pratt, the Mary Lee, and the Blue Creek, all of which are in the Warrior Basin, and the mining operations are in Jefferson, Walker and Tuscaloosa counties. Some coking coal is also produced from the Buck or Blocton No. 1 bed, in Bibb County.

Statistics of the manufacture of coke in Alabama, 1880-1911.

Year	Establishments	Ovens		Coal used (short tons)	Coke produced (short tons)	Total value of coke at ovens	Value of coke at ovens per ton	Yield of coal in coke (per cent.)
		Built	Building					
1880	4	316	100	106,283	60,781	$ 183,063	$3.01	57.0
1890	20	4,805	371	1,809,964	1,072,942	2,589,447	2.41	59.0
1900	30	6,529	690	3,582,547	2,110,837	5,629,423	2.67	58.9
1907	43	9,889	50	4,973,296	3,021,794	9,216,194	3.05	61.0
1908	45	10,103	0	3,875,791	2,362,666	7,169,901	3.04	61.0
1909	43	10,061	0	5,080,764	3,085,824	8,068,267	2.61	60.7
1910	43	10,132	340	5,272,322	3,249,027	9,165,821	2.82	61.6
1911	44	*10,121	†280	4,411,298	2,761,521	7,593,594	2.75	62.6

*Includes 280 Semet-Solvay and 60 Koppers ovens.
†Koppers by-product ovens.

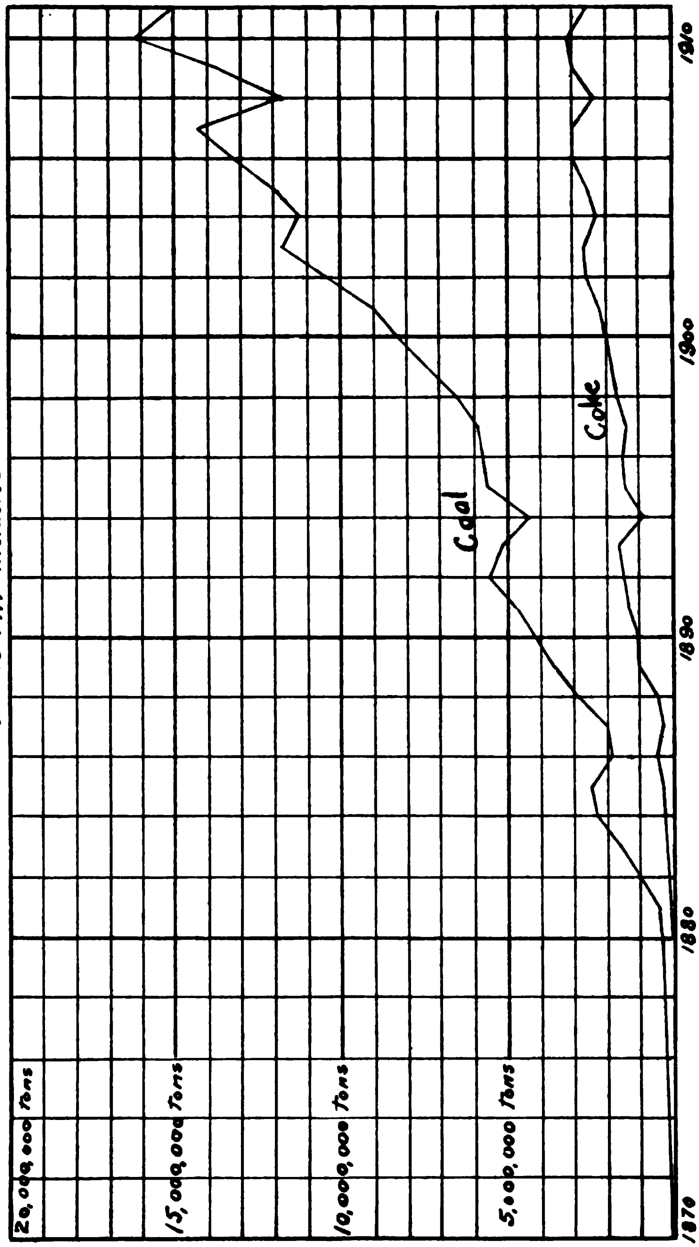
Out of a total of 4,411,298 short tons of coal made into coke in Alabama in 1911, about 55 per cent, or 2,420,117 tons, was washed slack. The washed run-of-mine coal used was a little over one-half the quantity of washed slack, or 1,295,109 tons. The unwashed coal used for coke making in Alabama in 1911 was 693,135 tons of unwashed mine-run and 2,937 tons of unwashed slack. The total quantity of washed coal used was 3,715,226 short tons, or about 84.2 per cent of the total quantity of coal made into coke.

The character of the coal used in the manufacture of coke in Alabama in 1890, 1900, and for the last five years, is shown in the following table:

Character of coal used in the manufacture of coke in Alabama, 1890-1911, in short tons.

Year	Run of mine		Slack		Total
	Unwashed	Washed	Unwashed	Washed	
1890	1,480,669	0	206,106	123,189	1,809,964
1900	1,729,882	152,077	165,418	1,535,170	3,582,547
1907	1,020,907	1,697,913	27,433	2,227,043	4,973,296
1908	548,093	1,457,360	53,218	1,817,120	3,875,791
1909	713,992	2,153,801	0	2,212,971	5,080,764
1910	771,981	1,308,035	0	3,192,306	5,272,322
1911	693,135	1,295,109	2,937	2,420,117	4,411,298

Curves showing the production of Coal and Coke, by tons, in Alabama from 1870 to 1911 inclusive



GOLD AND SILVER.

H. D. M'CASKEY.

THE mine production of gold in Alabama in 1911 was 915-06 fine ounces, valued at $18,916, and of silver, 171 fine ounces, valued at $91, against 1,622.16 fine ounces of gold, valued at $33,533, and 268 fine nounces of silver, valued at $145, in 1910. The value of the output decreased in 1911 therefore by $14,617 in gold and $54 in silver. The silver production is from recovery of this metal in refining the gold. No copper output and no placer production were reported from Alabama in 1911.

The mine production of Alabama in 1911 was from 6,360 short tons of siliceous ore with an average recovered value per ton in gold and silver of $2.99, against 9,763 tons averaging $3.41 in 1910 and 9,886 tons averaging $2.96 in 1909.

The output of 1911 was again mainly from the Hog Mountain mines in Tallapoosa County. The siliceous ores of this mine are in part oxidized and in part sulphides and they are treated in a 120-ton cyanide plant. No operations were reported at the Gold Ridge properties in Randolph County. At the Story prospect a small tonnage was treated in a 5-stamp amalgamation mill. The vein is in oxidized ore and is opened by an adit 150 feet long and a 75-foot shaft. Small trial shipments of gold ore only were made from the Holley prospect near Dadeville in Tallapoosa County.

Gold and Silver production in 1910 and 1911.

	Gold		Silver	
	Quantity oz.	Value	Quantity oz.	Value
1910	1,622.16	$33,533	268	$145
1911	915.06	18,916	171	91
Decrease	707.10	14,617	97	54
Per cent	43.59	43.59	36.19	37.24

GRAPHITE.

E. S. BASTIN.

GRAPHITE is widely distributed among the metamorphic rocks of Alabama, in which it occurs in two forms: (1) In the feebly crystalline schists which have been called Talladega slates, and which in part at least are Paleozoic sediments of as late age as the "Coal Measures," graphite is often found as a graphitic clay free from grit. In this condition the graphite is difficult to separate from the other matter with which it is mixed, and the material has not as yet been utilized to any important extent. Examples of this mode of occurrence may be been near Millerville, in Clay County, and about Blue Hill, in Tallapoosa County. (2) In the mica schists and other highly crystalline rocks, graphite is found in the form of thin crystalline flakes which may be separated from the associated minerals. Graphitic schists of this type are now being worked in three localities, and have in the past been worked at several others.

The more important localities where flake graphite occurs, including the two mines from which the 1911 production was obtained, are described briefly below.

CLAY COUNTY.

The two properties which are at present the leading producers in Alabama are located 4½ and 8 miles west of Ashland. Ashland, the shipping point, is the terminus of a short branch of the Atlanta, Birmingham & Atlantic Railroad. This branch is 7 miles long, and joins the main line at Pyriton. The freight rate on refined graphite from Ashland to New York City is about $7 per ton.

Allen Graphite Co.—The quarry and mill of this company, which was the largest producer in 1910, but which operated only three months in 1911, are located a little over 8 miles west of Ashland, at a settlement shown on the United States Geological Survey's map of the Ashland quadrangle under the name "Graphite." The mine is about one-half mile from

the mill, with which it is connected by a tramway. The concentrate is hauled over a fairly good road to Ashland for shipment. The mining is entirely from open pits, and because of the decomposed character of the rock can be accomplished largely with the aid of pick, shovel, and crowbar, without much drilling and blasting. The main pit is about 450 feet in length, 100 feet in average width, and about 60 feet in maximum depth. A small pit just east of the main pit and on the same graphitic band is about 100 feet long, 90 feet wide, and 25 feet deep. A third pit has been opened on the same band of graphitic schist about 1000 feet east of the main pit on the west face of another hill. This is about 90 feet wide, about 200 feet long, and about 40 feet deep. The strike of the schist at the north end of the main pit is N. 80° E., with a dip of 75° S. This is fairly typical for the deposit as a whole.

The rock mined is highly schistose, and is composed largely of quartz and graphite. A white fibrous mineral, probably sillimanite, is also abundant. Feldspar and mica are rare. Few of the thin graphite flakes so far seen by the writer exceed 2 millimeters across, and most of them were under 1½ millimeters. They are arranged subparallel to one another, and to this arrangement and a similar orientation of the sillimanite (?) prisms is largely due the schistosity of the rock. At the west end of the main pit a dike of coarse granite, 1 to 1½ feet wide, parallels the foliation of the schist, and in the easternmost pit the graphitic schist has also been intruded by an irregular body of coarse granite pegmatite carrying muscovite crystals up to 3 inches across. The graphitic beds here are also disturbed by faulting. The contact metamorphic effects of these small intrusions on the graphitic schist appear to be slight.

The milling process is divided into three principal stages: (1) Crushing and drying; (2) preliminary wet concentration; and (3) final dry concentration.

The most important step in the milling process is the preliminary concentration by water flotation. In these concentrators the dry crushed rock is spread in a thin stream upon the surface of slowly flowing water. The graphite being flaky is supported by the surface tension of the water and floats off, while the granular gangue, mainly quartz, sinks and is sent

to the dump. The process is cheap where water is plentiful. The tailings seen on the dump carry surprisingly little graphite; that which is present is usually attached to other minerals. Much fine grit of course floats off with the graphite, but is removed in the final dry concentration.

The crude rock is said by the operators to average about 5 per cent graphite. The finished product averages about 2.75 per cent by weight of the crude rock treated. Four principal grades are produced, whose relative proportions are about as follows:

Grades of Flake Graphite Produced by the Allen Graphite Co., Clay County, Ala.

	Per Cent.
Grade C. Crucible flake	36
Grade 1. Lubricating flake (coarse)	11
Grade 2. Lubricating flake (fine)	18
Grade D. Dust for foundry facings, etc.	35
	100

The highest grade contains over 90 per cent graphite; the dust averages about 50 per cent graphite. The prevailing average prices f. o. b. New York are: Grade C, 6½ cents per pound; grade 1, 5½ cents per pound; grade 2, 4½ cents per pound; and grade D, 1 cent per pound.

Ashland Graphite Co.—The quarry and mill of this company, which is the successor of the Enitachopco Graphite Co., are located 4½ miles west of Ashland. The product of the plant is hauled by teams to Ashland. The workings of this property consist of two open pits located in the same bed of graphite schist. The two pits are on neighboring knolls, and the mill is in the small valley between them. The largest or eastern pit is about 400 feet long, 30 to 50 feet wide, and 50 feet deep. It follows along the strike of a band of graphitic schist which averages about 30 feet in width, though broadening locally to about 50 feet. The strike is about N. 55° E., and the average dip is about 45° S. E. The second pit, located west of the mill, is about 150 feet long, 20 feet wide, and about 20 feet deep. The trend of the schists is similar to that at the larger pit.

The graphitic rock at this quarry is similar in general to that at the Allen quarry. The schist is too much decomposed for complete identification of all the minerals, but quartz is the principal component. As a rule mica is rare, but the brown mica, biotite, is common in a few places. The graphite forms thin flakes, mostly under 1 millimeter in diameter, although some reach 2 millimeters. No igneous rocks are found in association with the graphitic schist at this property. The rock being more or less decomposed, can be excavated with pick and crow-bar, with occasional blasting. It is loaded into tramcars and hauled to the mill.

The mill has a capacity of about 50 to 60 tons per day of 12 hours. The milling process is in general similar to that at the Allen mill, though differing in details. A dry pan is used in preliminary crushing. The water flotation separators are simliar to those at the Allen plant. The final dry concentration is accomplished by screens and burrstone mills, without the use of Hooper pneumatic concentrators.

CHILTON COUNTY.

Flaketown Graphite Co.—This company operates a quarry and mill in the valley of Chestnut Creek, about 3½ miles northeast of Mountain Creek station. The graphitic rocks lie in the west valley slope, and have been developed by a small open pit. South of this pit sufficient prospecting has been done to show that the deposit is of considerable size. The rock is a graphitic quartz schist very similar to those worked in Clay County. On account of its situation on a steep valley slope, which favors relatively rapid removal of weathered material, the remaining material is not so much decomposed as the deposits west of Ashland, in Clay County.

Small quantities of green micaceous material, probably muscovite, are present in some specimens, but in general, mica is rare. The strike of the schist folia at the main pit is N. 35° W., with a dip of 45° SW. A few hundred yards farther south the strike shifts to N. 20° W. and N. 15° W. A dike of granite pegmatite 1 foot wide intrudes the graphitic schist at the main pit. It parallels the foliation, and within 1 to 2 inches of

the schist, carries graphite in scattered flakes up to one-eighth of an inch in diameter.

An analysis made by the United States Geological Survey of a composite sample of graphitic schist, collected from a number of different exposures on this property, showed 4.63 per cent. of graphite. The mill is located at the quarry, and during part of the year electric power for its operation is generated by water power from a 20-foot dam on Chestnut creek. Auxiliary steam power is also installed. Very little material has yet ben marketed, the plant being still in an experimental stage. Mountain Creek is the nearest shipping point.

This plant reported no production in either 1910 or 1911.

COOSA COUNTY.

A graphite deposit is located about 2 miles northwest of Goodwater, a station on the Central of Georgia Railway. At this locality a large number of small prospect pits are scattered over an idea of several acres, and nearly all show graphite quartz schist. The prospects are on a steep southwest hillside overlooking the iron bridge where the wagon road from Goodwater to Pine Grove crosses Hatchet Creek. The rock is gray when fresh, and highly schistose, and strikes nearly east and west, with a dip of about 45° S. It is almost identical in character with the graphitic schist worked in Clay County, and consists largely of quartz and graphite, the latter in flakes mostly under 1 millimeter in diameter. Very little mica is present. An analysis of a composite sample of graphitic schist collected from a large number of pits on this property showed 2 per cent of graphite, but in certain portions the percentage will undoubtedly be greater. The deposit is unquestionably a large one, and its situation on a steep hillside would afford opportunity to work to a considerable depth by open pit methods. The neighboring Hatchet Creek would furnish abundant water for wet concentration of the graphite.

A second deposit, probably of similar character, has been prospected between Mount Olive and Hollins, and is said to be of considerable size.

The foregoing description is from "Mineral Resources of the United States, 1910."

PRODUCTION.

The Alabama production, as usual, was all of the crystalline variety. There was a notable decrease in production as compared with 1910, because the Allen Graphite Co., of Quenelda, only operated for the first three months of the year. The mine and mill of this company were taken over during the year by persons associated with the American Flake Graphite Co., of Pennsylvania, and will be operated under the name of the Quenelda Graphite Co. The Ashland Graphite Co., of Ashland, is also undergoing reorganization and a new mill is in process of erection.

Production of Graphite in 1910 and 1911.

	Quantity Lbs.	Value	Percentage of Total U. S. Quantity	Percentage of Total U. S. Value
1910	1,577,977	$54,688	2.03	14.49
1911	820,000	39,000	1.40	13.51
Decrease	757,977	15,688		
Per cent	48.43	28.67		

IRON ORE.

EUGENE A. SMITH.

IRON ores of Alabama in the order of their economic importance are (1) red ore or hematite; (2) the brown ore or limonite; (3) the gray ore. The black band and clay iron stone have been noticed as occurring in a number of places, but only the red ore and the brown ore have been mined on any large scale.

Practically all the ore mined in Alabama is smelted in the State, the shipments out of the State being about equal to those received from other states.

The tables given below will show the rank of Alabama among the States of the Union both in the production of iron ore and in pig iron, and will show also the quantity of iron produced by charcoal and by coke respectively as fuel.

Red Ore or Hematite.

Practically all the ore of this quality mined in Alabama occurs in the Clinton or Red Mountain formation. The Red Mountain ridges occur on each side of the anticlinal valleys which separate the coal fields. In places the red ore ridges are lacking on one side, usually the western, of the valleys being cut out by faults, while on the other hand the ridge may be duplicated on one side of the valley by the same faults.

In most of the valley occurrences the moderate dips of the ore bed are on the eastern side and there are also practically all of the ore mines. Murphrees Valley makes an exception to this, the moderate dips and the iron mines being on the western side. The iron ore occurs mainly in the central part of the formation in seams or beds one to five in number, which vary in thickness from a few inches to thirty feet.

While the ore seams are very persistent along the outcrop which in Alabama must be as much as 50 miles, yet they vary greatly from place to place, being either too thin or too lean for profitable working in the greater part of this distance.

The most important development of the Clinton ore in this State and in the world is along the 15 or 16 mile stretch of

the east Red Mountain between Birmingham and Bessemer, and there is a practically continuous series of mines and strippings for this entire distance. Much mining of this ore has also been done near Gate City, Village Springs, Attalla, Gadsden, Round Mountain, Gaylesville, Ft. Payne, Valley Head, etc.

Production and Value of Hematite in Alabama in 1910 and 1911.

	Quantity Tons	% of total U. S. Prod.	Value	% of total U. S. value
1910	3,678,139	7.12	$4,376,555	3.39
1911	3,119,696	3.48	3,646,925	4.65
Decrease	558,443		729,630	
Per cent	15.18		16.67	

The average price per long ton of hematite in Alabama in 1910 was $1.19; in 1911, $1.17.

BROWN ORE OR LIMONITE.

This ore, the second in importance in the State and in the United States, furnished only 4.63 per cent of the total iron ore production of the United States in 1911. Of this Alabama produced 43.96 per cent, 835,886 long tons, and the State holds the *first* rank in this industry.

In the early days of iron making and up to the year 1876 this was the only ore used in the catalan forges, bloomaries, and charcoal furnaces of the State. It was then demonstrated that good iron could be made at low cost from the red ores, with coke for the fuel.

In general the limonites are considered the best of the ores of Alabama and they command the highest prices and command a ready sale.

The usual mode of occurrence is in irregular masses of concretionary origin in the residual clays resulting from the decomposition of limestones, and as a consequence the mining is uncertain and expensive. Limonite also occurs in regularly stratified seams or beds, and then it is the result of the alteration of pyrites or of carbonate ores. Practically all of the

brown ore actually mined is that occurring in the residual clays above mentioned. Most of the ore before going to the furnace is washed and screened, and this manipulation, together with the cost of mining, makes it the most expensive of the iron ores, and it is therefore seldom used alone, but is usually mixed with the red ore in proportions determined by the quality of the iron desired. It is used alone in the charcoal furnaces and also in the coke furnaces when a particularly tough pig iron is wanted.

The limonite deposits are very numerous and are distributed over a broad expanse of country and in many places are known to be very extensive. In some of the deposits are ore is in nearly solid mass, in others it is much scattered, and in consequence the amount of foreign material necessary to be moved for every ton of ore produced, varies very much, not only in the different ore banks but also in the different parts of the same bank.

The deposits occur in nearly all the geological formations of the state, but in most of these the ore is either insufficient in quantity or not pure enough to be of much commercial value. The most important of the deposits, in point of extent and value, occur overlying the following formations, viz., the Knox Dolomite and the Weisner Quartzite, the Lauderdale Chert of the Lower Carboniferous, and the Lafayette. Some extensive beds of ore of inferior quality generally, occur also in the Tuscaloosa formation of the Cretaceous, and in the upper part of the Lower Carboniferous and in the Metamorphic rocks.

The average price per long ton of limonite ore in Alabama in 1910 was $1.53; in 1911, $1.47.

Production and Value of Brown Ore in Alabama in 1910 and 1911.

	Quantity	% of total U. S. Prod.	Value	% of total U. S. value
1910	1,123,136	39.15	$1,707,167	35.28
1911	835,886	43.96	1,229,181	39.18
Decrease	287,250		477,086	
Per cent	25.57		27.94	

Production of Iron Ore in Alabama in 9110 and 1911.

	Hematite (Long Tons)	Brown Ore (Long Tons)	Total Quantity	Value	% of total U. S. value
1910	3,678,189	1,123,186	4,801,275	$6,083,722	4.32
1911	3,119,696	835,886	3,955,582	4,876,106	5.64
Decrease	558,443	287,250	845,693	1,207,616	-------
Per cent decrease	15.18	25.57	17.61	19.85	-------

In the following table the first five States in the production of iron ore are arranged according to their rank as producers in 1910 and 1911, with regard to both the quantity and the value of the ore produced:

Rank of iron-ore producing States in 1910 and 1911, with quantity and value of product and percentage of each.

1910.

Rank	State	Production: Quantity, in long tons	Production: Percentage of total product'n	Rank	State	Value: Amount	Value: Percentage of total value
1	Minnesota	31,966,769	56.19	1	Minnesota	$78,462,560	55.75
2	Michigan	13,303,906	23.39	2	Michigan	41,398,585	29.41
3	Alabama	4,801,275	8.44	3	Alabama	6,083,722	4.32
4	New York	1,287,209	2.26	4	New York	3,848,683	2.74
5	Wisconsin	1,149,551	2.02	5	Wisconsin	3,610,349	2.57

1911.

ORE MARKETED.

1	Minnesota	23,398,406	57.08	1	Minnesota	$48,447,760	56.06
2	Michigan	8,944,398	21.82	2	Michigan	23,808,935	27.55
3	Alabama	3,955,582	9.65	3	Alabama	4,876,106	5.64
4	New York	1,057,984	2.58	4	New York	2,959,009	3.42
5	Virginia	610,871	1.49	5	Wisconsin	1,386,616	1.60

Kinds of Ore Produced in Alabama, and Values of same in 1910 and 1911.

	Hematite				Brown Ore				Total		Per cent of U. S. total	
	Quantity (Long Tons)	% of total State Prod.	Value	% of total State value	Quantity (Long Tons)	% of total State Prod.	Value	% of total State value	Quantity (Long Tons)	Value	Quantity	Value
1910	3678139	76.6	$4376555	71.93	1123136	23.39	$1707167	28.07	4801275	$6083722	8.43	4.32
1911	3119696	78.86	3646925	74.79	835886	21.14	1229181	25.21	3955582	4876106	9.65	5.64
Decr's.	558443	----	729630	----	287250	----	477086	----	845693	1207616	---	---
Per ct.	15.18	----	16.67	----	25.57	----	27.94	----	17.61	19.85	---	---

Iron-ore mines of Alabama that produced more than 50,000 long tons each in 1911.

Rank	Name of Mine	Nearest Town	Variety of Ore	Quantity
1	Wooward	Woodward	Hematite	502,471
2	Raimund, No. 1	Bessemer	Hematite	178,793
3	Songo	Birmingham	Hematite	161,912
4	Raimund, No. 2	Bessemer	Hematite	131,314
5	Ironaton	Ironaton	Brown Ore	114,860
6	Clinton	Steinman	Hematite	111,374
7	Crudup	Gadsden	Hematite	99,486
8	Raimund, No. 3	Bessemer	Hematite	84,775
9	Woodstock	Woodstock	Brown Ore	83,362
10	Etowah	Gadsden	Hematite	68,133
11	Attalla	Attalla	Hematite	65,372
	Total (11 mines)			1,601,352
	Unspecified* (6 mines)			1,890,209
	Total of mines (23) producing less than 50,000 tons			464,021
	Grand total			3,955,582

*Includes the product of 6 mines producing over 50,000 tons each, operated by 2 companies, which do not permit the publication of individual statistics.

PIG IRON AND STEEL.

THE following table gives the quantity and approximate value of the pig iron produced in the five states leading in the production of pig iron, and shows the increase or decrease, both by totals and by percentages, for 1910 and 1911.

Quantity and value of pig iron produced in the United States in 1910 and 1911, by States, in long tons.

State	1910		1911		Decrease in 1911		Perc'tage of decrease in 1911	
	Quantity	Value (Dollars)	Quantity	Value (Dollars)	Quantity	Value (Dollars)	Quantity	Value
Pennsylvania	11,014,652	174,486,833	9,581,109	136,328,507	1,433,543	38,158,326	13.01	21.87
Ohio	5,584,279	85,385,254	5,371,378	73,484,592	212,901	11,900,662	3.81	13.94
Illinois	2,606,335	41,465,543	2,036,081	31,152,927	570,254	10,312,616	21.88	24.87
Alabama	1,969,770	24,127,616	1,617,150	17,379,171	352,620	6,748,445	17.90	27.97
New York	1,895,018	31,698,623	1,537,201	23,924,194	357,817	7,769,429	18.88	24.51

The figures above given are from the U. S. Geological Survey.

The following tables have been furnished by Mr. J. M. Swank of the American Iron and Steel Association, and Mr. Wm. G. Gray of the Bureau of Statistics of the American Iron and Steel Institute. The difference in the statistics for 1910 and 1911, are due to the fact that the figures of the U. S. Geological Survey represent shipments while the others represent the actual production.

Production of pig iron in Alabama, 1907-1912.

J. M. Swank and Wm. G. Gray.

Year	Coke Pig Iron Long Tons	Charcoal Pig Iron Long Tons	Total Long Tons
1907	1,651,583	35,141	1,686,725
1908	1,373,199	23,815	1,397,014
1909	1,729,976	33,641	1,763,617
1910	1,903,443	35,704	1,939,147
1911	1,679,654	32,557	1,712,211
1912	1,828,648	34,033	1,862,681

Alabama Production of Rolled Iron and Steel (including Rolled Forging Blooms and Rolled Forging Billets) from 1907 to 1911, inclusive.

J. M. Swank and Wm. G. Gray.

Year	Iron	Steel	Total
1907	44,728	238.569	283,297
1908	4,417	269,235	273,652
1909	1,267	256,705	257,972
1910	6,419	420,052	426,471
1911	3,550	353.059	356,609

LIME.

C. A. ABELE.

THE total production of thirteen operators in 1911 was 76,-406 short tons, a decrease from 1910 of 5290 short tons, or 6.47 per cent. The value of the product was $300,787, a decrease of $2,825, or 0.93 per cent.

Below is a table giving the production and value of lime in 1910 and 1911, and a comparison of these years.

Production of Lime in 1910 and 1911.

	Number of Operators	Quantity Short Tons	Rank of State by quantity	Value	Rank of State by value	Average price per ton	Percentage of total U. S value
1910	14	816,96	15	$303,612	13	$3,72	2.19
1911	13	76,406	15	300,787	16	3.94	2.19
Decrease	------	5,290	------	2,825	------	------	------
Percentage decrease	------	6.47	------	0.93	------	------	------

The most important use of the lime produced, as in 1910 was for building purposes, nearly 60 per cent of the total product being used for this purpose, the remainder being used in chemical plants, sugar refineries, tanneries, for fertilizer, or was distributed through dealers.

Shelby County was the largest producer, having produced 49,256 tons, or 64.46 per cent of the total. The other producers in the order of their rank were Etowah, Blount, Jackson, Calhoun and Colbert counties.

Below is an outline of some of the chemical processes in which lime may be used:

Chemical uses of lime.

E. F. Burchard.

Agricultural industry:
- As a soil amendment, c, m.*
- As an insecticide, c, m.
- As a fungicide, c, m.

Bleaching industry:
- Manufacture of bleaching powder, "Chloride of lime," c.
- Bleaching and renovating of rags, jute, ramie, and various paper stocks, c, m.

Caustic alkali industry:
- Manufacture of soda, potash, and ammonia, c.

Chemical industries:
- Manufacture of ammonia, c.
- Manufacture of calcium carbide, calcium cyanimid, and calcium nitrate, c.
- Manufacture of potassium dichromate and sodium dichromate, c.
- Manufacture of fertilizers, c, m.
- Manufacture of magnesia, m.
- Manufacture of acetate of lime, c.
- Manufacture of wood alcohol, c.
- Manufacture of bone ash, c, m.
- Manufacture of calcium carbides, c.
- Manufacture of calcium-light pencils, c.
- In refining mercury, c.
- In dehydrating alcohol, c.
- In distillation of wood, c.

Gas manufacture:
- Purification of coal gas and water gas, c, m.

Glass manufacture:
- Most varieties of glass and glazes, c.

Milling industry:
- Clarifying grain, c, m.

Miscellaneous manufactures:
- Rubber, c, m.
- Glue, c, m.
- Pottery and porcelain, c, m.
- Dyeing fabrics, c, m.
- Polishing material, c, m.

Oil, fat, and soap manufacture:
- Manufacture of soap, c.
- Manufacture of glycerine, c.
- Manufacture of candles, c.
- Renovating fats, grease, tallow, butter, c, m.
- Removing the acidity of oils and petroleum, c, m.
- Lubricating greases, c, m.

Paint and varnish manufacture:
- Cold-water paint, c, m.
- Refining linseed oil, c, m.
- Manufacture of linoleum, c, m.
- Manufacture of varnish, c, m.

Paper industry:
- Soda method, c.
- Sulphite method, m.
- For strawboard, c, m.
- As a filler, c, m.

Preserving industry:
- Preserving eggs, c.

Sanitation:
- As a disinfectant and deodorizer, c.
- Purification of water for cities, c.
- Purification of sewage, c.

Smelting industry:
- Reduction of iron ores, c, m.

Sugar manufacture:
- Beet root, c.
- Molasses, c.

Tanning industry:
- Tanning cowhides, c.
- Tanning goat and kid hides, c, m.

Water softening and purifying, c.

*High calcium lime is indicated by ',c," magnesian and dolomitic lime by "m."

MICA.

BY DOUGLAS B. STERRETT.

THE most prominent feature of the minerals of the mica group is their perfect cleavage into tough, flexible, and elastic sheets. The ready cleavage combined with transparency and nonconductivity of electricity render mica valuable in the industrial world. The commercial demand has practically been supplied by two varieties, muscovite and phlogopite, but a small quantity of biotite has been used. Only muscovite and phlogopite have been found in masses of sufficient size and abundance to meet the demands of the trade.

Muscovite, called "white mica," is a silicate of aluminum and potassium containing water; phlogopite, called "amber mica," is a silicate of magnesium, aluminum, and potassium; biotite is a silicate of magnesium, iron, aluminum, and potassium. Phlogophite and biotite may be placed at opposite ends of a chemical series and may grade into each other by variations in the percentage of iron present. In thin sheets muscovite is nearly colorless, phlogopite generally yellow or brownish, and biotite dark brown to black. In sheets of one-sixteenth of an inch or more in thickness muscovite may be colorless, white, gray, yellow inclining to amber, red, brown, or green; phlogopite may be yellow, brown, or black, and sometimes coppery; and biotite is black. Muscovite of a reddish color is often called "rum" and "ruby" mica. The luster of muscovite is brilliant and glimmering on fresh surfaces, and that of phlogophite is less brilliant and more silvery or pearly.

USES.

Mica has a wide commercial application, both in the form of sheet mica and of ground mica. The most extensive use of sheet mica is in the manufacture of electrical apparatus, but a considerable quantity is still used in the glazing trade for stoves, for gas-lamp chimneys, for lamp shades, etc. The demand for mica for glazing is small and only the best quality and the larger sheets are thus used. Both large and small

sheet mica is used in the electrical industry. "Micanite," or built-up mica board, for the manufacture of which small-sheet mica can be used, is substituted for large-sheet mica in much electrical work. Mica serves as a perfect insulator in various parts of dynamos, motors, induction apparatus, switch-boards, lamp sockets, and nearly every variety of electrical appliance.

The domestic or muscovite mica is satisfactory for all insulation except for commutators of direct-current motors and dynamos built up of bars of copper and strips of mica. For this purpose no mica is as satisfactory as the phlogophite or "amber mica." This mica is of about the same hardness as the copper of the commutator segments and therefore wears down evenly without causing the machine to spark.

A large quantity of scrap mica—small sheets and the waste from the manufacture of sheet mica—is ground for different uses. Among these are the decoration of wall paper and the manufacture of lubricants, fancy paints, and molded mica for electrical insulation. Ground mica applied to wall papers gives them a silvery luster. When mixed with grease or oils finely ground mica forms an excellent lubricant for axles and other bearings. Mixed with shellac or special compositions ground mica is molded with desired forms and is used in insulators for trolley wires. Ground mica for electrical insulation must be free from metallic minerals. Mica used for lubrication should be free from gritty matter. For wall paper and brocade paints a ground mica with a high luster is required, and such luster is best obtained by using a clean light-colored mica and grinding it under water. Coarsely ground or "bran" mica is used to coat the surface of composition roofing material to prevent the tar or other composition used in its manufacture from sticking when the material is rolled for shipping.

From The Mineral Resources of Alabama, 1904, by Eugene A. Smith and Henry McCalley.

"While mica has not been sent from Alabama to the market in anything more than an experimental way, yet there is much reason for thinking that a good mercantile article can be obtained at a number of points in Chilton, Coosa, Clay and Randolph counties. In a belt of mica schists extending through these counties, there are frequent veins of a coarse grained

granite or pegmatite, in which the constituent minerals, quartz, feldspar, and mica are segregated in large masses. The feldspar is very generally weathered into kaolin, and it is from these occurrences that we get all the true or vein kaolin. The mica in its turn is present in the form generally of large rough masses or boulders, from which it may be split out in sheets of varying size. In all this belt there are ancient pits or mines in which trees are now growing with a diameter of 18 inches.

Around the mouths of these old diggings are great piles of broken-up refuse mica, apparently showing that a large amount of the mineral had been taken from them. In North Carolina, and probably elsewhere, the old mines of this kind have often proven to be the best places for obtaining good mica in modern times, and this fact may serve as a hint to those who contemplate mica mining in this State.

Most work in getting mica has probably been done near Micaville, in Cleburne county, and at the Pinetucky mine, in Randolph. Many tons of mica, some of it in large sheets six to ten inches in size, have been gotten up and stored away in a house, which was destroyed by fire and the mica injured, so that it has never been sent to market. None of the localities is near a railroad. A little testing, (it can hardly be called mining) has also been done in several places in Clay County, and also in Coosa and Chilton."

PRODUCTION.

There was only one producer of mica operating in 1911, and as this mine was opened only in the latter part of the year, the production was rather light, reaching only 65,000 pounds.

MINERAL WATERS.

G. C. MATSON.

ACCORDING to the returns received from spring owners, the mineral-water trade of Alabama continued to prosper during 1911, sales increasing from 133,159 gallons reported during 1910 to 205,854 gallons in 1911, an increase of 72,695 gallons, or 54.59 per cent. The value, however, owing to a decline of 10 cents per gallon in the average price for the year, decreased 11.94 per cent, or from $30,639 in 1910 to $26,982 in 1911. No new springs were reported during 1911. Two springs which failed to report in 1910 reported in 1911, and one spring reporting in 1910 was idle in 1911; hence, the total number of springs increased from 9 to 10. About three-fourths of the total sales of mineral water in Alabama is used medicinally. There are resorts at 6 of the springs, accommodating more than 700 people, and the water at 2 is said to be used for bathing purposes. In addition to the quantity reported as sold, there were 5,000 gallons used for the manufacture of soft drinks.

The following 10 springs reported sales:

Bailey Springs, Florence, Lauderdale County.
*Bladon Springs, Bladon Springs, Choctaw County.
Blount Springs, Blount Springs, Blount County.
Bromberg Gulf Coast Lithia Springs, Bayou La Batre, Mobile County.
Cherokee Spring, near Citronelle, Mobile County.
Healing Springs, Healing Springs, Washington County.
Ingram Lithia Wells, near Ohatchee, Calhoun County.
Livingston Mineral Springs, Livingston, Sumter County.
Luverne Mineral Springs, Luverne, Crenshaw County.
MacGregor Springs, Spring Hill, Mobile County.
Matchless Mineral Wells, east of Greenville, Butler County.

The following table shows the relative productions, and their respective values, for 1910 and 1911.

*The Bladon Water Co. sold mineral water from these springs in 1911, and for some years previous to this, but figures showing quantity and value of the water were not available.

Production of Mineral Waters in 1910 and 1911.

	Number of Springs	Quantity Sold	Average Retail price	Value of Medicinal Waters	Value of Table Waters	Total value of Mineral Waters	Percentage of total U. S. value
1910	9	133,159	$0.23	$23,179	$7,460	$30,639	0.48
1911	10	205,854	0.15	20,244	6,738	26,982	0.39
Increase or decrease	+ 1	+ 726.95	− 0.08	− 2,935	− 722	− 3,657	------
Per cent	----	+ 54.59	− 34.68	− 12.66	− 9.69	− 11.93	------

In the latter part of 1912 a number of owners of local mineral springs, whose production is small, and having only a limited distribution, signified a willingness to report their sales, which will probably materially increase Alabama's output in the future.

SAND AND GRAVEL.

C. A. ABELE.

THE total production of sand and gravel in the State in 1911 was 677,894 short tons, valued at $215,413, as compared with 619,253 short tons, valued at $187,291 in 1910, a net increase in quantity of 58,641 short tons, or 9.47 per cent, and an increase of $27,822, or 14.83 per cent in value.

The following tables give the production, value, and disposition of the sand and gravel produced in 1910 and 1911, and a comparison of these years.

Production and Value of Sand in 1910 and 1911.

	Molding Sand		Building Sand		Paving Sand		Furnace Sand		Other Sands		Total	
	Quantity Tons	Value	Quantity Tons	Value	Quantity Tons	Value	Quantity Tons	Value	Quantity Tons	Value	Quantity Tons	Value
1910	56085	$22069	228797	$73567	-----	- ----	286	$148	22547	$4477	307715	$100261
1911	52766	19432	201214	70284	10975	$ 3635	36540	7738	14988	7891	356293	119758
Increase or Decr.	− 3319	− 2637	− 27583	− 3283	-----	- ----	+36254	+7590	− 7559	+ 2914	+ 48578	+ 19497
Per cent	− 5.91	−11.95	− 12.05	− 4.46	-----	------	-------	------	−33.52	+65.08	+ 15.78	+ 19.44

Production of Sand and Gravel in 1910 and 1911.

	Sand		Gravel		Total		Percentage of total U. S. value
	Quant'y	Value	Quant'y	Value	Quant'y	Value	
1910	307,715	$100,261	311,538	$87,330	619,253	$187,591	0.89
1911	356,293	119,758	321,601	95,655	677,894	215,413	1.018
Increase	48,578	19,497	10,063	8,325	58,641	27,822	-------
Per cent	15.78	19.44	3.23	9.53	9.47	14.83	-------

STONE.

E. F. BURCHARD.

THE figures presented in the following report have to do with the stone produced and sold by the quarrymen and include only such manufactured product as is put on the market by the quarrymen themselves. This applies especially to rough and dressed building stone, dressed monumental stone, crushed stone, flagstone, curbstone, and paving blocks. The value given to this manufactured product is the price received by the producer, free on board at point of shipment, and includes therefore the cost of labor necessary to dress the stone. The stone reported as sold rough includes stone sold as rough stock to monumental works, and to cut-stone contractors for building purposes; stone sold as riprap, rubble, and flux; and includes the value of only such labor as is required to get the stone out of the quarry in the shape required by the purchaser. The value given to this stone is the price received by the quarryman free on board at point of shipment. In case the stone is sold to local trade the value is given as the quarryman sells the material, generally at the quarry, but in some cases delivered, if this is done by the producer. In some instances a long haul to market or to the railroad increases the cost of the material, and therefore of the selling price.

PRODUCTION.

C. A. ABELE.

Alabama produces commercially only three kinds of stone, namely, limestone, sandstone, and marble. The most important use of the limestone is blast furnace flux, roadmaking, building and crushed stone for concrete following in the order of their importance. No sandstone for building purposes was reported in 1911, the principal use of this stone being found in the manufacture of concrete, and on dam construction on the Coosa and Tallapoosa Rivers. The value of the marble

produced may not be divulged, as there was only one producer in 1911 as in 1910.

Below is a table giving the value of the limestone and sandstone producer in the past five years, from 1907 to 1911.

Value of Stone Production from 1907 to 1911.

Kind	1907	1908	1909	1910	1911
Limestone	$694,699	$479,730	$700,642	$714,516	$561,798
Sandstone	48,673	34,099	77,327	109,063	73,195

LIMESTONE.

The value of the limestone burned into lime, or used in the manufacture of Portland cement, is not taken into account under this heading, but is included in the value of each of the finished products in whose manufacture it is used.

As thus limited, the total value of limestone produced in 1911 was $561,748, as compared with $714,516 in 1910, a decrease of $152,718, or 21.09 per cent.

The values of the limestone producer during the last five years are given below for comparison.

Production of Limestone from 1907 to 1911.

1907	1908	1909	1910	1911
$694,699	$479,730	$700,642	$714,516	$561,798

The values of limestone produced in 1910 and 1911, classified according to the uses of the stone, are given in the following table:

Value of Limestone produced in 1910-1911.

	1910	1911	Increase or Decrease	Per cent.
Rough Building	$1,901	$2,115	+ $214	+ 11.25
Dressed Building	34,001	29,652	— 4,349	— 12.79
Paving	4,500	170	— 4,330	— 98.00
Curbing	-------	150	----------	------------
Riprap	37,505	10,459	— 27,046	— 72.11
Road Making	64,872	37,511	— 27,361	— 42.17
Railroad Ballast	5,842	------	----------	------------
Concrete	16,199	23,077	+ 6,878	+ 42.46
Flux	545,988	458,356	— 87,632	— 16.05
Other	3,708	308	— 3,400	— 91.69
Total	$714,516	$561,798	— $152,718	— 21.09
Percentage of total U. S. value	2.62	1.66	----------	------------

LIMESTONE FOR BUILDING PURPOSES.

EUGENE A. SMITH.

From the tables above it will be seen that by far the largest part of the limestone for other purposes than lime burning produced in Alabama 1910-1911, has been for flux rock in the iron furnaces. Crushed stone for road making and riprap follow next, and then dressed building stone.

The preparation of cut stone for building purposes in Alabama, while on the increase, is not yet what it should be. Practically all of this material comes from the quarries in the Subcarboniferous limestone of the Tennessee Valley, the most important quarries being at Rockwood in Franklin County, operated by Foster-Freighton-Gould Co., of Nashville. This stone is quite similar in appearance, composition, and other qualities to the Indiana stone, and so far as experience in the use of the stone from the two localities in the buildings of the University of Alabama goes, the Alabama stone holds its own under influence of the weather better than does the Indiana stone. Stone steps, door sills, and window sills, buttress caps, etc., of the Alabama stone put in place in 1885 show practically no deterioration in color and wear under

foot, and in crumbling and roughening under the influence of the weather, which can not be said of some portions of the Indiana stone used in buildings erected in 1909-10. The Rockwood quarries have most modern and approved methods of machinery for sawing the stone and handling it in transit to the mills and elsewhere. The stone is of massive formation, of great thickness and extent. Blocks weighing as much as 25 tons, without crack or flaw, are not infrequently quarried, the size of the blocks being practically limited only by the capacity of the hoisting machinery.

The Oolitic variety is most extensively used for building and monumental work. It is of light gray color, uniform grain, and homogeneous texture. It possesses a quality of cheapness, it can be cut to any design required, and is at the same time strong and durable.

At the present time the business at this quarry is confined to the furnishing of rough and sawed stone to the cut stone contractor or dealer.

With the installing of adequate machinery at the quarry for doing the finished work, there should never be any longer any reason for going outside of the State for this quality of stone. Already the material has been very extensively used in public buildings in Mississippi, Tennessee, as well as in Alabama. The only reason why it was not used in the recently erected buildings at the University of Alabama was that at the time these building contracts were let, the quarries furnished only the rough sawn stone and there was not in Alabama any establishment adequately equipped for the dressing of the stone in the quantity needed.

MARBLE.

EUGENE A. SMITH.

The marble of Alabama is of two kinds, crystalline or true marble and non-crystalline.

The crystalline or statuary marble occurs mainly in a narrow valley along the western border of the metamorphic area, extending from Marble Valley in Coosa County, through Talladega into Calhoun. The length of the marble belt through Coosa and Talladega counties is about 50 miles. The width of the valley carrying the marble as a rule is from one quarter to one half mile, widening in places to a mile and a quarter, for example in the neighborhood of Sylacauga.

The quarries longest known are Gantt's and Herd's near Sylacauga, Nix's near Sycamore, and Taylor's and McKenzie's near Taylor's Mill East of Talladega. From all these marble was quarried before the civil war.

During1911 only 2 establishments had reported any marble production, viz: The Alabama Marble Co., at Gantt's Quarry near Sylacauga and the Alabama-Carara Marble Co. near Talladega. Several other companies, however, have made some rather extensive developments and will no doubt report some production in 1912 and later. These are the Eureka Marble Co. (Bishop's) near Talladega Springs; the Morretti-Harrah Marble Co., Sylacauga; and the Alabama Marble Quarries of the Scott Brothers near Sycamore.

The plant of the Alabama Marble Company at Gantt's Quarry was destroyed by fire in December, 1910, and it was not until the middle of August, 1911, that the rebuilding was completed and production begun. From that time till the end of the year the production was as stated below:

Blocks	**17781** Cu. ft.
Unfinished sawed stock	**7928** Cu. ft.
Finished stock of all kinds	**47639** Cu. ft.
Total finished stock	**73348** Cu. ft.
Scrap and broken stone	**1457 tons**

The cubic feet above stated are, in all cases, the net measure of the quantities sold, with all waste in quarrying, sawing, and finishing eliminated.

I think it is fairly safe to say that on the whole the marble from this quarry and immediate vicinity is of the highest grade of commercial white marble now on the market and obtainable in large quantity. There are small quantities of marble produced both in Italy and Vermont that are somewhat freer from coloring matter than the best grades that can be produced in Alabama in any quantity. But on the other hand, the poorest grades in Alabama greatly surpass the poorest grades produced elsewhere, so that the average of the Alabama deposit is probably somewhat higher than that of any other so far developed, not excluding even the marble from the Carara district in Italy. The marble from this State (Gantt's Quarry) has now a well established reputation and has been used in more than 150 important buildings throughout the United States.

It can be seen in the galleries of the National Museum in Washington.

A beautiful quality of variegated limestone or marble—red, pink and white—belonging probably to the Cambrian formation, occurs in Shelby County a mile or two south of Shelby Springs station on the L. & N. railroad, and extending thence southwest for a mile or two. Nothing but prospecting work has been done on this marble. The Trenton limestone in the Appalachian valleys, particularly Jones Valley below Bessemer, contains marble similar to that quarried in the vicinity of Knoxville, Tenn. Also at Pratt's ferry on the Cahaba River in Bibb County a quarry was for many years worked in this formation and turned out a very beautiful quality of marble varying in color from gray through pink, red, and brown shades.

A black marble which is exceedingly promising, has been reported and some development work done near Anniston, Calhoun County, and some very handsome specimens of cave onyx have been obtained from near Kymulga in Talladega County.

In the Coastal Plain the St. Stephens limestone of the Tertiary holds ledges of hard, almost crystalline rock capable of taking good polish. The colors vary from nearly white, through shades of yellowish into red, and it would make a handsome decorative marble, especially for inside work.

Other limestone formations, such as the Subcarboniferous and the Knox Dolomite, could in places be drawn upon for marble.

SANDSTONE.

The value and distribution of the sandstone produced in 1911, with a comparison of 1910 and 1911, is given in the table below:

Value and Uses of Sandstone Produced in 1910 and 1911.

	Rough Building	Ganister	Rubble	Riprap	Crushed Stone for Concrete	Total	% of total U. S. value
1911	----	12,700	14,362	16,133	30,000	73,195	.94
1910	$100	$12,088	$20,802	$20,073	$56,000	$100,063	1.37
Increase or decrease	----	+ 612	— 6,440	— 3,940	— 26,000	— 53,868	-----
Per cent	----	+ 5.06	— 30.96	— 14.64	— 46.42	— 32.88	-----

SUMMARY OF THE MINERAL PRODUCTION OF ALABAMA IN 1911.

ON account of the different units of measurement employed in the mineral industry, a summation of the production of the year can include only values of the products. It is also to be noticed that a simple summation of all the values of the minerals, or mineral products listed in this pamphlet would give a value somewhat in excess of the true value, since in many cases, as for instance, coal and coke, the second product is directly a product of the first. To give the values of both as a part of the total would be to repeat, in a measure, a partial value of the first or raw product, and would give an erroneous result.

According to this manner of summation, 1907 was the first and only year in which the value of the Alabama production reached or passed the $50,000,000 mark. The result of the financial depression of 1907 is apparent in the decrease in value of the mineral products of 1908, which declined $17,125,941, or approximately 32 per cent from the 1907 value. In 1909 and 1910 the general recovery in business increased the total values to $41,982,208, and $47,751,109 respectively. In 1911 the decline in pig iron and the decreased coal production brought the total value of the year down to $40,203,712, a decrease of $7,547,397, or 15.6 per cent.

In 1911 coal took the lead as the most valuable product, the others being, in the order of the value, pig iron, brick and tile, limestone, cement, sand and gravel, sandstone, bauxite, pottery, and miscellaneous, including marble, graphite, gold and silver, mica, natural gas, and abrasives.

The following table shows how the total value of the mineral products of the state varied during the last five years:

The total value of the Mineral Products of Alabama from 1907 to 1911.

Year	Value	% of total U. S. value
1907	$52,186,749	2.51
1908	35,010,808	2.19
1909	41,982,208	2.22
1910	47,751,109	2.39
1911	40,203,712	2.09

PROBABLE FUTURE PRODUCTION.

THE following minerals have been produced in Alabama in past years, but no production was reported for 1911: Fullers Earth, Manganese ore, Ocher, Pyrite. Since all these occur in quantity and of quality to make them of commercial value, the production may be resumed at any time.

Among the probable productions in the near future, are natural gas and petroleum, onyx marble, turquoise and other minerals noticed in the Index to the Mineral Resources of Alabama a publication of the State Geological Survey.

Natural gas under pressure of 630 pounds has been obtained from several wells in Fayette and Walker Counties, and smaller quantities under less pressure have been obtained near Huntsville and elsewhere.

A Report with map on the Fayette County Gas Field has been published by the survey during the year. No commercial production has yet been reported.

11720

GEOLOGICAL SURVEY OF ALABAMA

EUGENE ALLEN SMITH, *State Geologist*

BULLETIN No. 15

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1912

COMPILED FROM MINERAL RESOURCES OF THE UNITED STATES

TRANSFERRED TO GEOLOGICAL SCIENCES LIBRARY

BY
CHARLES ARTHUR ABELE

UNIVERSITY, ALABAMA
1913

GEOLOGICAL SURVEY OF ALABAMA

EUGENE ALLEN SMITH, *State Geologist*

BULLETIN No. 14

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1912

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By
CHARLES ARTHUR ABELE

UNIVERSITY, ALABAMA
1913

PRESS
BROWN PRINTING CO.
MONTGOMERY
ALABAMA

LETTER OF TRANSMITTAL.

UNIVERSITY, ALA., November, 1913.

HON. EMMET O'NEAL,

Governor of Alabama,

Montgomery, Ala.

SIR:—I have the honor to transmit herewith the manuscript of a Report on the Mineral Production of Alabama for the year 1912, with the request that it be printed as Bulletin No. 14 of the Geological Survey of Alabama.

Very respectfully,

EUGENE A. SMITH,

State Geologist.

GEOLOGICAL CORPS.

Eugene Allen Smith, Ph. D.	State Geologist
William F. Prouty, Ph. D.	Chief Assistant
S. J. Lloyd, Ph. D.	Assistant
Robert S. Hodges	Chemist
Herbert H. Smith	Curator of Museum
Roland M. Harper, Ph. D.	Botanist
George N. Brewer	Field Assistant
C. A. Abele	In Charge of Mineral Statistics
A. T. Donoho	Stenographer.

RIVER GAGE HEIGHT OBSERVERS.

C. J. Stowe	Jackson's Gap, Tallapoosa River
J. E. Whitehead	Riverside, Coosa River
S. T. Dillard	Beck, Conecuh River
Ed. Bullin	Red Bay, Big Bear Creek
E. Cummings	Wedowee, Little Tallapoosa River

From the records of daily observations of the gage readings at these places when extended through sufficient time, the calculations of available horsepower to be obtained from the different streams is made.

TABLE OF CONTENTS.

PREFACE.

The statistics of all the minerals included in the following pages have been collected in cooperation with the United States Geological Survey, and have been compiled by Mr. Abele from advance chapters of the *Mineral Resources of the United States*, a publication of the Federal Survey.

The introductory and general matter in each of these articles has either been taken without change from the U. S. advance chapters or has been rearranged or condensed from these chapters, or entirely rewritten to suit it for our present purposes. In each case credit is given to the author.

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1912.

ABRASIVES.

EUGENE A. SMITH.

ALABAMA'S production of abrasives is at present limited to a small number of millstones; there are, however, several materials in different parts of the State which are sufficiently promising to be worth investigation and thorough testing; the nature and locality of these deposits were treated in Bulletin No. 13, which see.

BAUXITE.

THE production of bauxite in Alabama in 1912 was 14,173 long tons valued at $60,254. This was an increase of 5,325 long tons, or 60.18 per cent over the production of 1911, and the increase in value amounted to $24,862, or 70.25 per cent.

Below are presented in tabular form the foregoing figures:

Production of bauxite in Alabama in 1911 and 1912.

	Quantity (Tons)	Value	Percentage of Total U. S. Production.	Percentage of Total U. S. Value.
1911	8,848	$35,392	5.68	4.71
1912	14,173	60,254	8.86	7.83
Increase	5.325	24,862		
Per cent	60.18	70.25		

The following table gives the production and value of Bauxite from 1889 to 1912 inclusive:

Production of bauxite in the United States, 1889-1912, by States, in long tons.

<table>
<tr><th>Year</th><th>Georgia</th><th>Alabama</th><th>Arkansas</th><th>Total</th><th>Value</th></tr>
<tr><td>1889</td><td>728</td><td>-------</td><td>-----------</td><td>728</td><td>$2,366</td></tr>
<tr><td>1890</td><td>1,844</td><td>-------</td><td>-----------</td><td>1,844</td><td>6,012</td></tr>
<tr><td>1891</td><td>3,301</td><td>292</td><td>-----------</td><td>3,593</td><td>11,675</td></tr>
<tr><td>1892</td><td>5,110</td><td>5,408</td><td>-----------</td><td>10,518</td><td>34,183</td></tr>
<tr><td>1893</td><td>2,415</td><td>6,764</td><td>-----------</td><td>9,179</td><td>29,507</td></tr>
<tr><td>1894</td><td>2,050</td><td>9,016</td><td>-----------</td><td>11,066</td><td>35,818</td></tr>
<tr><td>1895</td><td>3,756</td><td>13,313</td><td>-----------</td><td>17,069</td><td>44,000</td></tr>
<tr><td>1896</td><td>7,313</td><td>11,051</td><td>-----------</td><td>18,364</td><td>47,338</td></tr>
<tr><td>1897</td><td>7,507</td><td>13,083</td><td>-----------</td><td>20,590</td><td>57,652</td></tr>
<tr><td>1898</td><td>-------</td><td>-------</td><td>-----------</td><td>25,149</td><td>75,437</td></tr>
<tr><td>1899</td><td>15,736</td><td>14,499</td><td>5,045</td><td>35,280</td><td>125,598</td></tr>
<tr><td>1900</td><td colspan="2">19,739</td><td>3,445</td><td>23,184</td><td>89,676</td></tr>
<tr><td>1901</td><td colspan="2">18,038</td><td>867</td><td>18,905</td><td>79,914</td></tr>
<tr><td>1902</td><td colspan="2">22,677</td><td>4,645</td><td>27,322</td><td>120,366</td></tr>
<tr><td>1903</td><td colspan="2">22,374</td><td>25,713</td><td>48,087</td><td>171,306</td></tr>
<tr><td>1904</td><td colspan="2">21,913</td><td>25,748</td><td>47,661</td><td>235,704</td></tr>
<tr><td>1905</td><td colspan="2">15,173</td><td>32,956</td><td>48,129</td><td>240,292</td></tr>
<tr><td>1906</td><td colspan="2">25,065</td><td>50,267</td><td>75,332</td><td>368,311</td></tr>
<tr><td>1907</td><td colspan="2">---------------</td><td>-----------</td><td>*97,776</td><td>480,330</td></tr>
<tr><td>1908</td><td colspan="2">14,464</td><td>*37,703</td><td>52,167</td><td>263,968</td></tr>
<tr><td>1909</td><td colspan="2">22,227</td><td>*106,874</td><td>129,101</td><td>679,447</td></tr>
<tr><td>1910</td><td colspan="2">33,096</td><td>*115,836</td><td>148,932</td><td>716,258</td></tr>
<tr><td>1911</td><td colspan="2">30,170</td><td>*125,448</td><td>155,618</td><td>750,649</td></tr>
<tr><td>1912</td><td>19,587</td><td>14,173</td><td>*126,105</td><td>159,865</td><td>768,932</td></tr>
</table>

*Production of Tennessee included.

For an outline of the uses of bauxite, see Bulletin No. 13.

CEMENT

OWING to the fact that there was in Alabama in 1912 only one producer of puzzolan cement, and not more than two operating plants in the Portland cement industry, it is necessary to combine the productions of both industries in order to avoid publishing figures which were given the Survey in confidence. The tabular results of such a combination are, however, necessarily inconsistent and not to be taken too literally, since the weights per barrel of the two kinds of cement vary.

The total quantity of Portland and puzzolan cement produced in Alabama in 1912 was 726,688 barrels, valued at $608,620, as compared with 593,911 barrels in 1911, valued at $529,359, or an increase in production of 132,777 barrels, or 22.35 per cent, giving an increase in value of $119,261, or 22.53 per cent. The percentages of increase in quantity and value are notably less than in 1911.

Below are presented in tabular form the foregoing figures:

Production and value of cement (including puzzolan and Portland) in Alabama in 1911 and 1912.

	No. of Producers	Quantity (Bbls.)	Value	Value of Total U.S. Percentage
1911	3	593,911	$529,359	0.79
1912	3	726,688	608,620	0.92
Increase		132,777	119,261	
Per cent.		22.35	22.53	

A review of the puzzolan cement industry in the United States for the past five years is given in the following table:

Statistics of the Puzzolan-Cement Industry, 1908-1912.

	1908	1909	1910	1911	1912
Number of plants reporting production:					
Alabama	1	1	1	1	1
Illinois	------	------	------	------	------
Kentucky	------	------	------	------	------
Maryland	------	------	------	------	------
New Jersey	------	------	------	------	------
New York*	------	------	------	1	1
Ohio	2	2	2	1	1
Pennsylvania	1	1	1	1	1
Total	4	4	4	4	4
Production in barrels of 380 pounds	151,451	160,646	95,951	93,230	91,864
Value of production	$95,468	$99,453	$68,286	$77,786	$77,363

*Includes production of Collos cement in 1911 and 1912.

For a full account of the cement resources of Alabama, see Bulletins No. 8 and No. 13.

CLAY AND CLAY PRODUCTS.

JEFFERSON MIDDLETON AND C. A. ABELE.

CLAY.

CLAY available for the manufacture of clay products is one of the most widely spread of our minerals. Clay miners are usually also the manufacturers of the lower-grade clays, but as the higher grades of ware are reached, the rule is that fewer and fewer manufacturers are also miners, until in the highest grades of ware the rule is that the manufacturer is not the miner of the clays that he uses. The figures given in the following tables represent clay that is mined and not manufactured by the miner, but is sold as clay. The clay thus sold is small in quantity compared with that consumed and includes mainly clay used for refractory products.

The clay-mining industry showed a marked increase in Alabama in 1912, both in production and value. While the production was less than 60 per cent of that in 1910, the value was only 12 per cent less than in that year.

The total production of clay, which was later sold as such in 1912, was 43,052 short tons, valued at $33,414. This was an increase in both quantity and value of 8,249 short tons, or 23.43 per cent, and $3,505, or 11.72 per cent respectively. In 1912 clay other than fire-clay was again sold.

Below is a table giving the production and value of clay from 1908 to 1912, inclusive, and also a comparison of the years 1911 and 1912.

Production of clay from 1908 to 1912 inclusive, and a comparison of the production in 1911 and 1912.

	Fire-Clay		Miscellan. Clay		Total	
	Quantity Short Tons	Value	Quantity Short Tons	Value	Quantity Short Tons	Value
1908	68,289	$48,983	24,000	$12,000	92,289	$60,983
1909	45,137	35,845	18,271	5,587	63,408	40,932
1910	54,482	32,395	20,600	5,650	75,082	38,045
1911	35,203	29,909	------	------	35,203	29,909
1912	38,552	31,414	4,500	2,000	43,052	33,414
Increase	3,349	1,505	------	------	8,249	35,05
Per cent.	9.15	5.03	------	------	23.43	11.72

Quantity and value of clay mined in 1912.

Kind	Quantity Mined (Short Tons)	Value	Average Value Per Ton	Percentage of Total U. S. Value
Fire clay	38,552	$31,414	$0.81+	1.33
Miscellaneous clay	4,500	2,000	0.44+	0.76
Total	43,052	33,414	----------	0.89

Clay-Working Industries.

The total value of all clay products in Alabama in 1912 was $1,935,179, a decrease of $11,923, or 0.61 per cent, from 1911. The principal product is common brick, this item in 1912 being valued at $759,409 and representing 39.24 per cent of the value of all of Alabama's clay products in that year. Vitrified, fire, and front brick combined represent a value approximating that of common brick alone, so that the output of the brickyards made up nearly 80 per cent of the State's total. Clays suitable for tile and pottery are available in the State, but these branches of the industry have not been extensively developed, the value of the pottery production being only $22,213 in 1912.

Jefferson County is the principal clay-working county, reporting a production valued at $1,135,339, or 58.67 per cent, of the value reported for the State. All of the fire brick produced in the State is reported from Jefferson County, though vitrified brick is the principal product. Only one other county in the State, St. Clair, produces vitrified brick. The leading counties in the manufacture of common brick are Jefferson, Montgomery and Russell.

Clay products of Alabama, 1908-1912

Product	1908	1909	1910	1911	1912
Brick:					
Common—					
Quantity	120,237,000	146,180,000	135,785,000	129,694,000	136,989,000
Value	$690,963	$799,693	$746,961	$708,903	$759,409
Average per M.	$5.75	$5.47	$5.50	$5.47	$5.54
Vitrified—					
Quantity	18,248,000	20,444,000	19,772,000	21,444,000	26,480,000
Value	$244,084	$262,876	$236,516	$246,707	$358,308
Average per M.	$13.38	$12.83	$11.96	$11.50	$13.34
Front—					
Quantity	(*)	(*)	(*)	9,169,000	10,629,000
Value	(*)	(*)	(*)	$128,403	$132,033
Average per M.	$17.89	$16.19	$15.96	$14.00	$12.42
Fancy value	(*)	(*)	---------	(*)	(*)
Fire value	$122,354	$196,887	$163,672	$193,376	$240,434
Draintile value	$2,046	(*)	$3,773	$3,777	$5,465
Sewer pipe value	(*)	(*)	(*)	(*)	(*)
Fireproofing value	(*)	(*)	(*)	(*)	(*)
Pottery:					
Red earthenware value	$15,058	$11,886	$3,475	$11,243	$10,990
Stoneware and yellow and Rockingham ware value	$9,031	$24,453	$16,371	$14,753	$11,223
Miscellaneous value	$476,070	$404,832	$496,791	$639,941	$422,322
Total value	$1,559,606	$1,700,127	$1,667,559	$1,947,102	$1,935,179
Number of operating firms reporting	103	100	87	82	74
Rank of State	19	22	22	17	17

*Included in "Miscellaneous."

Brick and Tile.

The total common brick production in 1912 was 136,989 M, valued at $759,409. This represented an increase in both quantity and value of 7,295 M, or 5.62 per cent, and $50,506 or 7.13 per cent, respectively. The decrease in 1911 was over-

come in 1912, the 1912 production being 1,204 M more than in 1910, the resulting increase in value being $12,448. All other types of brick and tile production, excepting that of miscellaneous brick, showed a marked increase over that of 1911; miscellaneous brick, which includes those types which are manufactured by less than three producers, showed a notable decrease in value in 1912, the decrease in this one class being sufficient to counteract the increase in value of all other classes and to lower the value of the 1912 production $5,640 or 0.29 per cent.

The following tables give a review of the brick and tile industry in Alabama in 1911 and 1912.

Production of brick and tile in 1912

Kind	Quantity M.	Value	Av'g. Value per M.	Percentage of Total Value of Brick & Tile	Percentage of Total U. S. Value
Common Brick	136,989	$759,409	$5.54	39.69	1.46
Vitrified brick	26,480	353,303	13.34	18.46+	3.23
Front Brick	10,629	132,033	12.42	6.95	1.39
Fire Brick	9,930	240,434	24.21	12.55+	1.60
Drain Tile	----------	5,465	--------	0.28+	0.06
Miscellaneous	----------	*422,322	--------	22.06+	1.67
Total	----------	$1912,966	--------	100.00	1.40

*This value includes fancy brick, sewer pipe, fireproofing, and silica brick.

Production of brick and tile in 1911 and 1912.

Kind	1911			1912			Increase or Decrease in Value	Percentage
	Quantity	Value	Av'g. Price	Quantity	Value	Av'g. Price		
Common Brick	129,694	$708,903	$5.47	136,989	$759,409	$5.54	+$50,506	+ 7.13
Vitrified Brick	21,444	246,707	11.50	26,480	353,303	13.34	+106,596	+43.22
Front Brick	9,169	128,403	14.00	10,629	132,033	12.42	+ 3,630	+ 2.82
Fire Brick	11,929	193,375	16.21	9,930	240,434	24.21	+ 47,059	+24.33
Drain Tile	------	3,777	----	------	5,465	----	+ 1,688	+44.69
Miscellaneous	------	637,441	----	------	*422,322	----	—215,119	—33.74
Total	------	1,918,606	----	------	1,912,966	----	— 5,640	— 0.29

*Includes Fancy Brick, Sewerpipe, Fireproofing and Silica Brick.

POTTERIES.

The pottery industry of Alabama is of relatively small importance, as only the commoner and coarser grades of ware are produced, and most of this for local trade only. Production was reported by 15 operators whose total output was valued in 1912 at $22,213, which was a decrease of $6,283 from 1911. The products consisted entirely of red earthenware and stoneware in nearly equal proportions.

The following tables give the values of pottery produced in 1911 and 1912, and also a comparison of the production and values in these years.

Value of pottery products in 1912.

Kind	Value	Percentage of Total Alabama Potteries	Percentage of Total U. S. Value
Red Earthenware	$10,990	49.47+	1.14
Stoneware and Rockingham ware	11,223	50.52+	0.28+
Total	22,213	100.00	0.62

Comparison of pottery products in 1911 and 1912.

Kind	1911	1912	Decrease	Percentage
Red Earthenware	$11,243	$10,990	+ $253	2.25
Stoneware and Rockingham ware	17,253	11,223	6,030	34.95
Total	28,496	22,218	6,283	22.05

COAL.

E. W. PARKER.

TOTAL production in 1912, 16,100,600 short tons; spot value, $20,829,252. The returns to the Survey for the calendar year 1912 show that the preliminary estimates of the production published early in the year were considerably in excess of the actual output. The preliminary estimates indicated that the production would exceed the record of 16,111,462 short tons made in 1910. The final results show that it fell about 10,000 tons short of that figure, and amounted to 16,100,600 short tons. This was an increase of 1,079,179 tons, or 7.18 per cent, over 1911, when it amounted to 15,021,421 tons. The value increased somewhat more in proportion—$1,749,303, or 9.17 per cent—from $19,079,949 in 1911 to $20,829,252. The value of the 1912 production exceeded that of the slightly larger tonnage of 1910 by nearly $600,000. The principal local increases in 1912 were in Walker County, 444,367 tons; Jefferson County, 398,459 tons; St. Clair County, 220,542 tons, and Bibb County, 148,138 tons. Two counties showed decreases, Tuscaloosa, 150,691 tons, and Etowah, 84,552 tons.

Rank of first ten coal-producing States in 1911 and 1912, with quantity and value of products and percentage of each.

1911.

Production				Value			
Rank	State or Territory	Quantity (short tons)	Percentage of total proruct'n	Rank	State or Territory	Value	Percentage of total value
1	Pennsylvania:			1	Pennsylvania:		
	Anthracite	90,464,067	18.2		Anthracite	$175,189,392	28.0
	Bituminous	144,561,257	29.1		Bituminous	146,154,952	23.3
2	West Virginia	59,831,580	12.1	2	Illinois	59,519,478	9.5
3	Illinois	53,679,118	10.8	3	West Virginia	53,670,515	8.6
4	Ohio	30,759,986	6.2	4	Ohio	31,810,123	5.1
5	Alabama	15,021,421	3.0	5	Alabama	19,079,949	3.0
6	Indiana	14,201,355	2.9	6	Indiana	15,326,808	2.4
7	Kentucky	14,049,703	2.8	7	Colorado	14,747,764	2.4
8	Colorado	10,157,383	2.1	8	Kentucky	14,008,458	2.3
9	Iowa	7,331,648	1.5	9	Iowa	12,663,507	2.0
10	Virginia	6,864,667	1.4	10	Wyoming	10,508,863	1.7

1912.

Production				Value			
Rank	State or Territory	Quantity (short tons)	Percentage of total proruct'n	Rank	State or Territory	Value	Percentage of total value
1	Pennsylvania:			1	Pennsylvania:		
	Anthracite	84,361,598	15.8		Anthracite	$177,622,626	25.6
	Bituminous	161,865,488	30.3		Bituminous	169,370,497	24.4
2	West Virginia	66,786,687	12.5	2	Illinois	70,294,338	10.1
3	Illinois	59,885,226	11.2	3	West Virginia	62,792,234	9.0
4	Ohio	34,528,727	6.4	4	Ohio	37,083,363	5.3
5	Kentucky	16,490,521	3.1	5	Alabama	20,829,252	3.0
6	Alabama	16,100,600	3.0	6	Indiana	17,480,546	2.5
7	Indiana	15,285,718	2.8	7	Kentucky	16,854,207	2.4
8	Colorado	10,977,824	2.0	8	Colorado	16,345,336	2.4
9	Virginia	7,846,638	1.5	9	Iowa	13,152,088	1.9
10	Wyoming	7,368,124	1.4	10	Wyoming	11,648,088	1.7

The statistics of the production of coal in Alabama in 1911 and 1912, with the distribution of the product for consumption, are shown in the following table:

Coal production of Alabama in 1911 and 1912, by counties, in short tons.

1911.

County	Loaded at mines for shipment	Sold to local trade and used by employees	Used at mines for steam and heat	Made into coke	Total quantity	Total value	Average price per ton	Average number of days active	Average number of employees
Bibb	1,515,976	9,592	107,629	-------	1,633,197	$2,407,918	$1.47	239	2,631
Blount	80,266	1,900	100	-------	82,266	98,599	1.20	225	189
Etowah	252,866	720	2,274	-------	255,860	360,807	1.40	189	492
Jefferson	4,804,221	86,017	307,265	2,578,887	7,776,390	9,663,726	1.24	246	10,665
St. Clair	509,120	1,584	18,507	-------	529,211	673,576	1.27	240	682
Shelby	430,505	2,728	29,861	-------	463,089	757,772	1.64	240	866
Tuscaloosa	585,666	9,310	61,624	375,058	1,031,658	1,288,285	1.25	265	1,445
Walker	2,820,521	25,077	82,610	175,387	3,103,595	3,598,720	1.16	180	5,360
Winston	16,074	350	------	-------	16,424	25,185	1.50	67	129
Other counties* & small mines	120,348	3,918	5,465	-------	129,731	200,911	1.55	170	248
Total	11,135,568	141,191	615,335	3,129,332	15,021,421	19,079,949	1.27	227	22,707

1912.

County	Loaded at mines for shipment	Sold to local trade and used by employees	Used at mines for steam and heat	Made into coke	Total quantity	Total value	Average price per ton	Average number of days active	Average number of employees
Bibb	1,622,198	9,823	109,314	-------	1,781,335	$2,621,682	$1.47	272	2,948
Blount	143,603	1,139	1,600	-------	146,342	181,036	1.24	211	282
Etowah	166,366	3,067	1,875	-------	171,308	249,749	1.46	265	260
Jefferson	6,168,715	81,368	339,211	1,585,555	8,174,849	10,433,728	1.28	251	10,922
St. Clair	722,276	2,456	25,021	-------	749,753	959,219	1.28	291	725
Shelby	463,788	3,501	29,660	-------	496,949	872,501	1.76	250	878
Tuscaloosa	631,114	12,038	48,863	188,952	880,967	1,091,882	1.24	239	1,220
Walker	3,271,284	32,030	102,681	141,967	3,547,962	4,158,094	1.17	211	5,079
Winston	18,550	105	75	-------	18,730	27,798	1.48	220	57
Other counties† & small mines	124,627	2,059	5,719	-------	132,405	233,568	1.76	229	242
Total	13,372,521	147,586	664,019	1,916,474	16,100,600	20,829,252	1.29	245	22,613

*Cullman, DeKalb, Jackson, and Marion. †Cullman, Jackson, and Marion.

In the following table is presented a statement of the production of coal in Alabama, by counties, during the last five years, with increase and decrease in 1912 as compared with 1911:

Coal production of Alabama, 1908-1912, by counties, in short tons.

County	1908	1909	1910	1911	1912	Increase (+) or decrease (—), 1912.
Bibb	1,166,548	1,338,243	1,580,564	1,633,197	1,781,335	+ 148,138
Blount, Cullman	*181,062	*186,261	*235,456	*210,070	*276,429	+ 66,359
Etowah	8,880	46,194	172,465	255,860	171,308	— 84,552
Jefferson	5,914,129	7,176,922	8,298,702	7,776,390	8,174,849	+ 398,459
St. Clair	198,434	354,005	428,409	529,211	749,753	+ 220,542
Shelby	407,547	524,925	488,141	463,089	496,949	+ 33,860
Tuscaloosa	712,101	1,006,989	1,081,219	1,031,658	880,967	— 150,691
Walker	2,941,836	2,973,776	3,788,479	3,103,595	3,547,962	+ 444,367
Winston	28,408	32,278	16,442	16,424	18,730	+ 2,306
Other counties and small mines	50,648	63,857	21,585	1,927	2,318	+ 391
Total	11,604,593	13,703,450	16,111,462	15,021,421	16,100,600	+ 1,079,179
Total value	$14,647,891	$16,306,286	$20,236,853	$19,079,949	$20,829,252	+ $1,749,303

The great Appalachian coal region which furnishes over two-thirds of the coal production of the United States and which extends from Ohio and Pennsylvania on the north in a gradually narrowing belt through eastern Kentucky and Tennessee has its southern terminus in a considerably broadened area that occupies a large part of the northern half of Alabama. The coal-bearing formations of Alabama underlie about 8,400 square miles and are divided into four distinct basins, the Coosa, the Cahaba, and the Warrior, named from the rivers which drain them, and the Plateau, which includes Blount, Lookout, and Sand or Raccoon Mountains. By far the most important basin in area and in production is the Warrior, which includes all of Walker County, most of Jefferson, Tuscaloosa, and Fayette counties, and smaller parts of Blount, Cullman, Winston, and Marion counties. The area known to contain coal is approximately 4,000 square miles, or one-half the total coal area of the State, and contributes about 80 per cent of the total production.

There are several distinct coal groups in the basin, the most important of which are the Brookwood, the Pratt, and the Mary Lee, designated by the names of their principal beds. The Mary Lee group includes the Blue Creek, the Jagger, and the

Newcastle beds, most of which are mined in places. The Brookwood, the Pratt, and the Mary Lee produce most of the coking coal mined in the State, and more than half of all of the coal mined in the district.

The Cahaba Basin, second in importance, is a long narrow syncline, 68 miles long and about 6 miles wide, southeast of the Warrior, and occupies parts of St. Clair, Jefferson, Shelby, and Bibb counties. There are many workable beds and the total quantity of coal in the basin is large. The production is something over 10 per cent of the total for the State.

The Coosa Basin is a deep syncline east of the Cahaba and parallel with it, extending across Shelby and St. Clair counties. It is also long and narrow, 60 miles long by 6 miles wide. It has not been thoroughly explored, but in different parts of the area from two to twelve beds, 3 or more feet in thickness, have been reported.

The Plateau field embraces parts of Blount, Etowah, Dekalb, Cherokee, Marshall, and Jackson counties, and although it has an area underlain by coal four times that of the Cahaba and the Coosa combined, the resources in Alabama are comparatively small. There are four to six beds locally workable.

For maps of the Alabama coal fields, apply to the State Geologist, University of Alabama.

So far as known, the earliest record of the existence of coal in Alabama was made in 1834. The first statement of production in the State is contained in the United States census report for 1840, in which year the production is given as 946 tons. The census report for 1850 does not mention any coal production for the State, and the next authentic record is contained in the census statistics of 1860, when Alabama is credited with an output of 10,200 short tons. The mines of Alabama were probably worked to a considerable extent during the Civil War, but there are no records of the actual production until 1870, for which year the United States census reports a production of 11,000 tons. Ten years later the production had increased to 323,972 short tons, but the development of the present great industry really began in 1881 and 1882, when attention was directed to the large iron deposits near the city of Birmingham, and thus the great "boom" of that city and vicinity was inaugurated. By 1885 the coal pro-

duction of the State had increased to nearly 2,500,000 tons. Then followed a period of relapse and liquidation, which lasted two years, after which business settled down to a conservative and rational basis and has since developed steadily. In 1902 the coal production of the State reached a total of more than 10,000,000 tons, and reached the maximum of 16,111,462 tons in 1910.

The statistics of production in Alabama from 1840 to the close of 1912 are shown in the following table:

Production of coal in Alabama from 1840 to 1912, in short tons.

Year	Quantity	Year	Quantity	Year	Quantity	Year	Quantity
1840	946	1859	9,000	1878	224,000	1897	5,893,770
1841	1,000	1860	10,200	1879	280,000	1898	6,535,283
1842	1,000	1861	10,000	1880	323,972	1899	7,593,416
1843	1,200	1862	12,500	1881	420,000	1900	8,394,275
1844	1,200	1863	15,000	1882	896,000	1901	9,099,052
1845	1,500	1864	15,000	1883	1,565,000	1902	10,354,570
1846	1,500	1865	12,000	1884	2,240,000	1903	11,654,324
1847	2,000	1866	12,000	1885	2,492,000	1904	11,262,046
1848	2,000	1867	10,000	1886	1,800,000	1905	11,866,069
1849	2,500	1868	10,000	1887	1,950,000	1906	13,107,963
1850	2,500	1869	10,000	1888	2,900,000	1907	14,250,454
1851	3,000	1870	11,000	1889	3,572,983	1908	11,604,593
1852	3,000	1871	15,000	1890	4,090,409	1909	13,703,450
1853	4,000	1872	16,800	1891	4,759,781	1910	16,111,462
1854	4,500	1873	44,800	1892	5,529,312	1911	15,021,421
1855	6,000	1874	50,400	1893	5,136,935	1912	16,100,600
1856	6,800	1875	67,200	1894	4,397,178		
1857	8,000	1876	112,000	1895	5,693,775	Total	237,275,886
1858	8,500	1877	196,000	1896	5,748,697		

The evolution in making coke in the United States and the gradual shifting of this related industry from the coal-mining region to the centers of population and manufacture is interestingly shown in the statistics of coal production of Alabama. According to the returns the quantity of coal made into coke decreased from 4,417,443 tons in 1910 to 3,129,332 tons in 1911, and to 1,916,474 tons in 1912, whereas the actual quantities of coal made into coke in the State were 5,272,322 tons in 1910, 4,411,298 tons in 1911, and 4,585,498 tons in 1912. The reason for this apparent discrepancy lies in the fact

that in the two later years the proportion of coal made into coke in by-product ovens has materially increased and as these ovens are located at the blast furnaces, or in or near the larger cities, the coal shipped to them appears as a part of the product "loaded at mines for shipment" and not as coal made into coke at the mines. The quantity of Alabama coal made into coke in 1912 at points distant from the mines was nearly one and a half times that used at ovens near the mines.

Coal mining in Alabama in 1912 gave employment to 22,613 men for an average of 245 days, against 22,707 men for 227 days in 1911, the larger production in 1912 being accomplished through the additional working time. The average production per man in 1912 was 712 tons against 662 in 1911, but the average daily production per man was lower in 1912, 2.91 tons against 2.92 tons in 1911. Most of the mines in Alabama are operated 10 hours a day.

Average production per man compared with hours worked per day, and average number of days worked 1910-1912.

Year	8 hours		9 hours		10 hour		All others	Total		Average Tonnage	
	Mines	Men	Mines	Men	Mines	Men	Men	Men	Days Worked	Per Year	Per Day
1910	18	766	36	2,633	134	17,306	1,525	22,230	249	725	2.91
1911	15	550	50	5,345	102	12,628	4,184	22,707	227	662	2.92
1912	11	338	46	4,145	107	13,938	4,192	22,613	245	712	2.91

The production by machines increased from 2,936,512 tons in 1911 to 3,742,549 tons in 1912, and the percentage of machine-mined coal to the total increased from 19.6 to 23.2. There were 353 machines in use in 1912, an increase of 81 over 1911 and of 36 over 1910. Several mines equipped with machines were either idle or did not use their full equipment in 1911. Of the 353 machines in 1912, 222 were punchers, 60 were chain breast, 12 were long wall, and 59 short wall.

Number and kind of machines in use, and average production per man compared with production by machines, by short tons, in 1911 and 1912.

Year	Pick	Chain Breast	Long-Wall	Short-Wall	Total	Average Tonnage		Production by Machines	
						Per year	Per day	Total Tonnage by Machines	% of Machined Coal to State Total
1911	184	53	18	22	272	662	2.92	2,936,512	19.55
1912	222	60	12	59	353	712	2.91	3,742,549	23.2
Increase or decrease	+ 38	+ 7	— 1	+ 37	+ 81	+ 50	— .01	+ 806,037	----
Per cent	20.65	13.20	9.28	168.18	29.77	7.57	-----	20.64	----

Of the Alabama production not mined by machines 5,658,457 tons, or 35.1 per cent of the total, were shot off the solid, and 6,658,732 tons, or 41.4 per cent, were mined by hand.

Quantity and percentage of bituminous coal produced by different methods in 1911 and 1912.

Year	Mined by Hand	Percentage	Shot off the Solid	Percentage	Mined by Machines	Percentage	Not reported	Percentage	Total Production
1911	4,673,719	36.1	6,623,252	44.1	2,936,512	19.6	787,938	5.2	15,021,421
1912	6,658,732	41.4	5,658,457	35.1	3,742,549	23.2	40,862	0.3	16,100,600
Increase or decrease	+1,985,013	---	— 964,795	---	+ 806,037	---	—747,112	--	+1,079,179
Percentage	+ 42.49	---	— 14.56	---	+ 27.44	---	— 94.81	--	+ 7.18

There were 7,187,211 tons of coal washed in 1912, yielding 6,325,946 tons of cleaned coal and 861,265 tons of refuse. A large part of the washed coal is used for making coke.

Quantity and percentage of coal washed, by short tons, in 1911 and 1912.

	Quality of Coal Washed	Percentage of Coal Mined	Quantity of Clean Coal	Refuse	
				Quantity	% of Total Coal Washed
1911	6,251,828	41.61	5,538,401	713,427	11.41
1912	7,187,211	44.64	6,325,946	861,256	11.98
Increase	935,383	------	787,545	147,829	------
Percentage	14.96	------	14.22	20.72	------

According to the United States Bureau of Mines there were 121 fatal accidents in the coal mines of Alabama in 1912, a decided improvement over 1911, when, because, of several explosions and frequent deaths from windy shots, the aggregate number of fatalities was 209. Of the 121 deaths in 1912, 110 occurred underground, 61 of them due to falls of roof and coal, 25 to explosions of gas and dust, 11 to mine cars and locomotives, 9 to electrical shocks and burns, and 3 to explosives, including premature blasts, etc. Four deaths occurred in shafts and 7 on the surface.

There were no strikes of serious consequence during the year, the record showing 384 men idle for an average of 32 days.

Statistics of labor troubles 1910-1912.

Year	Number of Men on Strike	Percentage of Total Men Working	Total Days Lost	Average Number of Days Lost Per Man
1910	25	0.11	1,250	50
1911	210	0.92	1,260	6
1912	384	1.69	12,323	32

COKE.

E. W. PARKER.

ALABAMA'S output of coke in 1912 amounted to 2,975,489 short tons valued at $8,098,412, against 2,761,521 short tons, valued at $7,593,594, in 1911, the increase in 1912 being 213,968 tons, or 7.75 per cent, in quantity and $504,818, or 6.65 per cent, in value. Alabama retained in 1912 second place in the rank of coke-producing States, it having superseded West Virginia in 1911.

Rank of the first five states in the production of coke, 1907-1912.

State	1907	1908	1909	1910	1911	1912
Pennsylvania	1	1	1	1	1	1
Alabama	3	3	3	3	2	2
Indiana	—	—	—	—	—	3
West Virginia	2	2	2	2	3	4
Illinois	10	9	5	4	4	5

Comparison of the production and value of coke in Alabama in 1911 and 1912.

	No. of Ovens	Coal Charged (Short Tons)	Coke Produced (Short Tons)	Total Value of Coke Ovens	Percent of Total U. S. Value
1911	10,121	4,411,298	2,761,521	$7,593,594	9.02
1912	10,208	4,585,498	2,975,489	8,098,412	7.24
Increase	87	174,200	213,968	504,818	
Percentage	0.86	3.95	7.75	6.65	

The average price per ton for Alabama coke has declined from $2.82 in 1910 to $2.75 in 1911, and to $2.72 in 1912. This does not necessarily indicate an actual decline in the price of

coke. A large proportion, possibly over 90 per cent, of Alabama coke is consumed in furnaces which are owned by the same interests owning and operating the coal mines and coke ovens, and the placing of a value on the coke is largely a matter of accounting. The lower value per ton of the coke produced in 1912 was in spite of the fact that the value of the coal used advanced from $1.28 in 1911 to $1.35 in 1912.

That Alabama has developed her coking industry along the lines of modern practice is evinced by the fact that in each of the last three years the only new ovens under construction on December 31 were retort ovens. During 1912 there were 195 beehive ovens abandoned and 2 were rebuilt, a net loss in this type of ovens of 193. The number of retort ovens on the other hand, increased from 340 in 1911 to 620 in 1912, and there were 100 additional retort ovens under construction at the end of the year. The present installations of retort ovens in Alabama are 280 Semet-Solvay ovens and 340 Koppers ovens. The former include 240 Semet-Solvay ovens at Ensley (one-half completed in 1898 and the other half in 1902) and 40 at Tuscaloosa, which were completed in 1906. The 340 Koppers ovens include 60 completed during 1911 by the Woodward Iron Co., at Woodward, and 280 completed in 1912 by the Tennessee Coal, Iron & Railroad Co., at Corey. The 100 new ovens under construction at the end of the year consisted of 80 Koppers ovens building at Woodward and 20 Semet-Solvay ovens building at Tuscaloosa. There were 46 establishments in Alabama in 1912, an increase of 2 over 1911, but although 280 retort ovens were added during 1912 the total number of ovens increased only 87, or from 10,121 to 10,208, indicating that there was a decrease of 193 in the number of beehive ovens. Of the 46 establishments in Alabama, 18, with a total of 2,902 ovens, were idle. In addition to these there were 597 ovens, portions of other establishments, that were idle during the year. The number of active ovens was 6,709 and the average production per oven was 444 tons, against 337 tons per oven in 1911 and 338 tons in 1910, these figures again showing the influence of the operations of retort ovens on Alabama's production.

The production of coke in Alabama in 1880, 1890, 1900, and from 1908 to 1912 is shown in the following table:

Statistics of the manufacture of coke in Alabama, 1880-1912.

Year	Establishments	Ovens: Built	Ovens: Building	Coal Used (Short Tons)	Yield of Coal in Coke (per cent)	Coke Produced (Short Tons)	Total Value of Coke at Ovens	Value of Coke at Ovens Per Ton
1880	4	316	100	106,283	57.0	60,781	$183,063	$3.01
1890	20	4,805	371	1,809,964	59.0	1,072,942	2,589,447	2.41
1900	30	6,529	690	3,582,547	58.9	2,110,837	5,629,423	2.67
1908	45	10,103	0	3,875,791	61.0	2,362,666	7,169,901	3.04
1909	43	10,061	0	5,080,764	60.7	3,085,824	8,068,267	2.61
1910	43	10,132	340	5,272,322	61.6	3,249,027	9,165,821	2.82
1911	44	10,121	280	4,411,298	62.6	2,761,521	7,593,594	2.75
1912	46	*10,208	†100	4,585,498	64.9	2,975,489	8,098,412	2.72

*Includes 280 Semet-Solvay and 340 Koppers ovens.
†80 Koppers and 20 Semet-Solvay ovens.

Most of the coal used in the manufacture of coke in Alabama is washed before being charged into the oven. In 1912, out of a total of 4,585,498 tons, 3,819,400 tons, or 83 per cent, were washed. Of the washed coal used 2,922,979 tons were slack and 896,421 tons were run of mine. The unwashed coal was principally mine run, there being 747,305 tons of unwashed run-of-mine coal used and 18,793 tons of unwashed slack.

The character of the coal used in the manufacture of coke in Alabama in 1890, 1900, and for the last five years, is shown in the following table:

Character of coal used in the manufacture of coke in Alabama, 1890-1912, in short tons.

Year	Run of Mine: Unwashed	Run of Mine: Washed	Slack: Unwashed	Slack: Washed	Total
1890	1,480,669	0	206,106	123,189	1,809,964
1900	1,729,882	152,077	165,418	1,535,170	3,582,547
1908	548,093	1,457,360	53,218	1,817,120	3,875,791
1909	713,992	2,153,081	0	2,212,971	5,080,764
1910	771,931	1,308,085	0	3,192,306	5,272,322
1911	693,135	1,295,109	2,937	2,420,117	4,411,298
1912	747,305	896,421	18,793	2,922,979	4,585,498

GOLD AND SILVER.

H. D. M'CASKEY.

THE mine production of gold in Alabama in 1912 was 809.02 fine ounces, valued at $16,724, and of silver, 168 fine ounces, valued at $103, against 915.06 fine ounces of gold, valued at $18,916, and 171 fine ounces of Silver, valued at $91, in 1911. The gold output was all from gold-quartz mines in 1912 and the silver production was entirely from refining the gold bullion produced. No copper, lead, or zinc output was reported from Alabama in either 1912 or 1911.

The following table shows the mine production of gold and silver in Alabama since 1905, when the United States Geological Survey first collected detailed figures from the mines of the Eastern States:

Production of gold and silver in Alabama from 1905 to 1912 inclusive.

	Ore Sold or Treated (Short Tons)	Gold		Silver		Total Value
		Quantity oz.	Value	Quantity oz.	Value	
1905	16,425	2,009.0	$41,530	336	203	$41,733
1906	8,565	1,137.0	24,921	124	83	25,004
1907	18,400	1,256.9	25,982	439	290	26,272
1908	11,174	1,993.4	41,208	282	149	41,357
1909	9,886	1,414.4	29,239	212	110	29,349
1910	9,763	1,662.2	33,533	268	145	33,678
1911	6,360	915.0	18,916	171	91	19,007
1912	5,693	809.0	16,724	168	103	16,827
Increase or decrease in 1912	— 667	— 106.0	—2,192	— 3	+ 12	—2.180
Percentage	—10.48	— 11.58	—11.60	—1.75	+13.18	—11.47

The production for 1912 was from 5,693 short tons of siliceous ore with an average recoverable precious metal value of $2.96 per ton, against 6,360 tons and a recovery of $2.99 in 1911 and 9,763 tons and a recovery of $3.41 in 1910.

In Clay County, near Pyriton, are several pyrite mines, all idle in 1912, whose ores were formerly sold for their sulphur content and produced residues containing gold, silver, and copper. No operations were reported from the Gold Ridge properties in Cleburne and Randolph counties, although the last-named prospects were leased and may be operated in 1913. The equipment includes a 20-stamp mill and an 80-ton cyanide plant. At the Storey prospect in Talladega County a small tonnage was again treated during operations of about two months of the 5-stamp amalgamation mill. The Tallapoosa mine, of Tallapoosa County, was also operated a short time in 1912, and produced gold on a small scale. The output was again chiefly from the Hog Mountain, or Hillabee, mines in Tallapoosa County, operated in 1912 under lease. The ores treated in 1912 were oxidized, and were all cyanided in the 75-ton plant of the company.

GRAPHITE.

E. S. BASTIN.

THE plant of the Quenelda Graphite Co. (formerly the Allen Graphite Co.), at Quenelda, was destroyed by fire but is now being rebuilt with a capacity for handling 400 tons of crude material in 10 hours. No production was reported for 1912.

The Ashland Graphite Co.'s plant, about 4½ miles west of Ashland, was idle during 1912. Some of the persons interested in this company are engaged, under the name of the Alabama Graphite Co., in developing a graphite deposit of similar character in the near vicinity. A mill was erected and began operations in August, 1912.

Production and value of graphite in 1911 and 1912.

	Quantity Lbs.	Value	Percentage of Total U. S. Quantity	Percentage of Total U. S. Value
1911	820,000	$39,000	1.40	13.51
1912	534,100	21,364		
Decrease	285,900	17,636		
Percentage	34.86	45.20		

In addition to the production above given, the Alabama Graphite Company produced in 1912, 144,062 pounds, at the plant of the Ashland Graphite Company purchased by them. The total production for 1912 is, therefore, 678,162 pounds.

For a full account of the graphite deposits and workings of Clay, Chilton, and Coosa counties, see Bulletin No. 13.

IRON ORE.

EUGENE A. SMITH.

IRON ores of Alabama in the order of their economic importance are (1) red ore or hematite; (2) the brown ore or limonite; (3) the gray ore. The black band and clay iron stone have been noticed as occurring in a number of places, but only the red ore and the brown ore have been mined on any large scale.

Practically all the ore mined in Alabama is smelted in the State, the shipments out of the State being about equal to those received from other states.

The tables given below will show the rank of Alabama among the States of the Union both in the production of iron ore and in pig iron, and will show also the quantity of iron produced by charcoal and by coke respectively as fuel.

Red Ore or Hematite.

Practically all the ore of this quality mined in Alabama occurs in the Clinton or Red Mountain formation. The Red Mountain ridges occur on each side of the anticlinal valleys which separate the coal fields. In places the red ore ridges are lacking on one side, usually the western, of the valleys being cut out by faults, while on the other hand the ridge may be duplicated on one side of the valley by the same faults.

In most of the valley occurrences the moderate dips of the ore bed are on the eastern side and there are also practically all of the ore mines. Murphrees Valley makes an exception to this, the moderate dips and the iron mines being on the western side. The iron ore occurs mainly in the central part of the formation in seams or beds one to five in number, which vary in thickness from a few inches to thirty feet.

While the ore seams are very persistent along the outcrop which in Alabama must be as much as 50 miles, yet they vary greatly from place to place, being either too thin or too lean for profitable working in the greater part of this distance.

The most important development of the Clinton ore in this State and in the world is along the 15 or 16 miles stretch of the east Red Mountain between Birmingham and Bessemer, and there is a practically continuous series of mines and strippings for this entire distance. Much mining of this ore has also been done near Gate City, Village Springs, Attalla, Gadsden, Round Mountain, Gaylesville, Ft. Payne, Valley Head, etc.

The completion in October, 1912, of a diamond drill boring in Shades Valley, within a mile of the base of Shades Mountain, gives a definite answer to the speculations concerning the occurrence of red ore under Shades Valley. This boring shows that there is no falling off in the thickness and quality of the ore with distance from the outcrop, and that the depth of the ore below the surface at a distance of more than 2½ miles from the outcrop on Red Mountain is not too great for shaft mining.

The elevation of the surface at the drilling is 595 feet. The top of the ore was reached at a depth of 1,902 feet and a section of the seam in descending order is:

Ore (Self-fluxing)	9 ft. 6 in.
Shale	4 in.
Ore (Siliceous)	9 ft. 6 in.

An analysis of an average sample of the drill of the core of the upper bench, made by David Hancock, shows as follows:

	Per Cent.
Metallic iron	39.51
Silica	9.94
Alumina	3.34
Calcium Carbonate	24.20
Magnesium carbonate	.78
Metallic manganese	.20
Phosphorus	.32

The importance of this demonstration of a vast increase in the amount of red ore available immediately or in the near future, cannot well be overestimated.

Production and value of hematite in Alabama in 1911 and 1912.

	Quantity (Tons)	% of Total U. S. Prod.	Value	% of Total U. S. Value
1911	3,119,696	8.43	$3,646,925	4.65
1912	3,814,361	7.42	4,638,734	4.8
Increase	694,665	---	991,809	---
Percentage	22.26	---	27.19	---

The average price per long ton of hematite in Alabama in 1911 was $1.17; in 1912, $1.16.

Brown Ore or Limonite.

This ore, the second in importance in the State and in the United States, furnished only 2.92 per cent of the total iron ore production of the United States in 1912. Of this Alabama produced 46.40 per cent, 749.242 long tons, and the State holds the *first* rank in this industry.

In the early days of iron making and up to the year 1876 this was the only ore used in the catalan forges, bloomaries, and charcoal furnaces of the State. It was then demonstrated that good iron could be made at low cost from the red ores, with coke for the fuel.

In general the limonites are considered the best of the ores of Alabama and they command the highest prices and command a ready sale.

The usual mode of occurrence is in irregular masses of concretionary origin in the residual clays resulting from the decomposition of limestones, and as a consequence the mining is uncertain and expensive. Limonite also occurs in regularly stratified seams or beds, and then it is the result of the alteration of pyrites or of carbonate ores. Practically all of the brown ore actually mined is that occurring in the residual clays above mentioned. Most of the ore before going to the furnace is washed and screened, and this manipulation, together with the cost of mining, makes it the most expensive of the iron ores, and it is therefore seldom used alone, but is usually mixed with the red ore in proportions determined by the quality of the iron desired. It is used alone in the charcoal furnaces and also in the coke furnaces when a particularly tough pig iron is wanted.

The limonite deposits are very numerous and are distributed over a broad expanse of country and in many places are known to be very extensive. In some of the deposits the ore is in nearly solid mass, in others it is much scattered, and in consequence the amount of foreign material necessary to be moved for every ton of ore produced, varies very much, not only in the different ore banks but also in the different parts of the same bank.

The deposits occur in nearly all the geological formations of the state, but in most of these the ore is either insufficient in quantity or not pure enough to be of much commercial value. The most important of the deposits, in point of extent and value, occur overlying the following formations, viz., the Knox Dolomite and the Weisner Quartzite, the Lauderdale Chert of the Lower Carboniferous, and the Lafayette. Some extensive beds of ore of inferior quality generally occur also in the Tuscaloosa formation of the Cretaceous, and in the upper part of the Lower Carboniferous and in the Metamorphic rocks.

The average price per long ton of limonite ore in Alabama in 1911 was $1.47; in 1912, $1.43.

Production and value of brown ore in Alabama in 1911 and 1912.

	Quantity (Tons)	% of Total U. S. Prod.	Value	% of Total U. S. Value
1911	835,886	43.96	$1,229,181	39.18
1912	749,242	46.40	1,095,637	37.91
Decrease	86,644	----	133,544	----
Percentage	10.36	----	10.86	----

Production of iron ore in Alabama in 1911 and 1912.

	Hematite (Long Tons)	Brown Ore (Long Tons)	Total Quantity	Value	% of Total U. S. Value
1911	3,119,696	835,886	3,955,582	$4,876,106	5.64
1912	3,814,361	749,242	4,776,545	5,734,371	5.36
Increase or decrease	+ 694,665	— 86,644	+ 820,963	+ 858,265	-----
Percentage	+ 22.26	— 10.36	+ 20.75	+ 17.60	-----

In the following table the first five States in the production of iron ore are arranged according to their rank as producers in 1911 and 1912, with regard to both the quantity and the value of the ore produced:

Rank of iron-ore producing States in 1911 and 1912, with quantity and value of product and percentage of each.

	State	Mined: Quantity (Long Tons)	Mined: Percentage of Total Produc'n	Marketed: Quantity (Long Tons)	Marketed: Percentage of Total Produc'n	Marketed: Value: Amount	Marketed: Value: Percentage of Total Value
	1911.						
1	Minnesota	24,645,105	56.17	23,398,406	56.94	$48,447,760	55.87
2	Michigan	10,329,039	23.54	8,945,103	21.77	23,810,710	27.46
3	Alabama	3,827,791	8.72	3,955,582	9.63	4,876,106	5.62
4	New York	1,061,279	2.42	1,057,984	2.58	2,959,009	3.41
5	Wisconsin	698,660	1.59	610,871	1.49	1,146,188	1.32
	1912.						
1	Minnesota	34,431,768	62.43	34,249,818	60.07	$61,805,017	57.74
2	Michigan	11,191,430	20.29	12,797,468	22.44	29,003,168	27.09
3	Alabama	4,563,603	8.28	4,766,545	8.38	5,734,371	5.36
4	New York	1,216,672	2.21	1,167,405	2.05	2,938,024	2.74
5	Wisconsin	860,600	1.56	1,152,250	2.02	2,731,574	2.55

Iron-ore mines of the United States that produced more than 50,000 long tons each in 1912.

	Name of Mine	Nearest Town	Variety of Ore	Quantity
2	Raimund No. 1	Lipscomb	Hematite	471,264
1	Woodward No. 1, 2, & 3	Bessemer	Hematite	217,503
3	Songo	Songo	Hematite	173,578
4	Raimund No. 2	Bessemer	Hematite	159,043
5	Greeley	Greeley	Brown Ore	141,577
6	Steinman	Steinman	Hematite	126,695
7	Crudup	Gadsden	Hematite	122,651
8	Ironaton	Ironaton	Brown Ore	93,980
9	Docray	Docray	Brown Ore	77,169
10	Houston	Rickey	Brown Ore	68,763
11	Attalla	Attalla	Hematite	63,604
12	Tannehill	Goethite	Brown Ore	55,512
	Total (12 mines)			1,771,339
	Unspecified* (6 mines)			2,526,390
	Total of mines (23) producing less than 50,000 tons			468,816
	Grand Total			4,766,545

*Includes the product of 6 mines producing over 50,000 tons each, operated by 2 companies, which do not permit the publication of individual statistics.

PIG IRON.

Quantity and value of pig-iron marketed, by the five States in rank, in the United States in 1911 and 1912, with increase and percentage of increase in 1912, in long tons.

State	1911		1912		Increase in 1912		% of Increase in 1912	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Pennsylvania	9,581,109	$136,328,507	12,437,685	$181,569,299	2,856,576	$45,240,792	29.81	33.19
Ohio	5,371,378	73,484,592	7,127,176	93,140,369	1,755,798	19,655,777	32.69	26.75
Illinois	2,036,081	31,152,927	2,806,378	42,828,816	770,297	11,675,889	37.83	37.48
Alabama	1,617,150	17,379,171	1,987,753	21,371,053	370,603	3,991,882	22.92	22.97
New York	1,537,201	23,924,194	1,973,090	28,059,058	435,889	4,134,864	28.36	17.28

LIME.

C. A. ABELE.

ALTHOUGH the production of 1912 was 4.65 per cent greater than that of 1911, the increase was not sufficient to bring the total up to the amount of the 1910 production. The total product of 13 operators in 1912 was 79,957 short tons, an increase over 1911 of 3551 tons, or 4.65 per cent. The value of the product was $297,178, a decrease of $3,609, or 1.20 per cent.

Below is a table presenting some data on the lime production of 1911 and 1912.

Production of lime in 1911 and 1912.

	Number of Operators	Quantity (Short Tons)	Rank of State by Quantity	Value	Rank of State by Value	Average Price Per Ton	Percentage of Total U. S. Value
1911	13	76,406	15	300,787	16	3.94	2.19
1912	13	79,957	14	297,178	17	3.72	2.13
Increase or decrease	------	3,551	------	3,609	------	-------	-----
Percentage	------	4.65	------	1.20	------	-------	-----

The most important use of the lime produced, as in 1911, was for building purposes, more than 65 per cent of the total product being used for this purpose, the remaining portion being used in chemical plants, sugar refineries, tanneries, for fertilizer, or was distributed through dealers.

Shelby county was again the largest producer, having produced 47,859 short tons or over 59 per cent of the total production. The other producers in the order of their rank were Etowah, Blount, Calhoun, and Jefferson counties.

Following is an outline of some of the chemical processes in which lime may be used:

Chemical uses of lime.
E. F. Burchard.

Agricultural industry:
- As a soil amendment, c, m.*
- As an insecticide, c, m.
- As a fungicide, c, m.

Bleaching industry:
- Manufacture of bleaching powder, "Chloride of lime," c.
- Bleaching and renovating or rags, jute, ramie, and various paper stocks, c, m.

Caustic alkali industry:
- Manufacture of soda, potash, and ammonia, c.

Chemical industries:
- Manufacture of ammonia, c.
- Manufacture of calcium carbide, calcium cyanimid, and calcium nitrate, c.
- Manufacture of potassium dichromate and sodium dichromate, c.
- Manufacture of fertilizers, c, m.
- Manufacture of magnesia, m.
- Manufacture of acetate of lime, c.
- Manufacture of wood alcohol, c.
- Manufacture of bone ash, c, m.
- Manufacture of calcium carbides, c.
- Manufacture of calcium-light pencils, c.
- In refining mercury, c.
- In dehydrating alcohol, c.
- In distillation of wood, c.

Gas manufacture:
- Purification of coal gas and water gas, c, m.

Glass manufacture:
- Most varieties of glass and glazes, c.

Milling industry:
- Clarifying grain, c. m.

Miscellaneous manufactures:
- Rubber, c, m.
- Glue, c, m.
- Pottery and porcelain, c, m.
- Dyeing fabrics, c, m.
- Polishing material, c, m.

Oil, fat, and soap manufacture:
- Manufacture of soap, c.
- Manufacture of glycerine, c.
- Manufacture of candles, c.
- Renovating fats, grease, tallow, butter, c, m.
- Removing the acidity of oils and petroleum, c, m.
- Lubricating greases, c, m.

Paint and varnish manufacture:
- Cold-water paint, c, m.
- Refining linseed oil, c, m.
- Manufacture of linoleum, c, m.
- Manufacture of varnish, c, m.

Paper industry:
- Soda method, c.
- Sulphite method, m.
- For strawboard, c, m.
- As a filler, c, m.

Preserving industry:
- Preserving eggs, c.

Sanitation:
- As a disinfectant and deodorizer, c.
- Purification of water for cities, c.
- Purification of sewage, c.

Smelting industry:
- Reduction of iron ores, c, m.

Sugar Manufacture:
- Beet root, c.
- Molasses, c.

Tanning industry:
- Tanning cowhides, c.
- Tanning goat and kid hides, c, m.

Water softening and purifying, c.

*High calcium lime is indicated by "c," magnesian and dolomitic lime by "m."

MINERAL WATERS.

G. C. MATSON.

RETURNS from Alabama spring owners show that the output of mineral water declined both in quantity and in value during 1912. The total sales decreased from 205,854 gallons, valued at $26,982, in 1911, to 165,678 gallons, valued at $20,435, in 1912, a decline of 19.52 per cent in quantity and 24.26 per cent in value. The average price reported was 12.3 cents a gallon, against 15 cents as the average for 1911. Six new springs were reported during 1912, making a total of 16 springs. About one-half of the total sales of mineral water is used medicinally, and the water at six springs is said to be used for bathing purposes. In addition to the quantity reported as sold, 35,000 gallons were used for the manufacture of soft drinks.

The following 16 springs reported sales:

Alabama Mineral Springs, near Oakhill, Wilcox County.
Bailey Springs, Florence, Lauderdale County.
Bladon Springs, Bladon Springs, Choctaw County.
Blount Springs, Blount Springs, Blount County.
Bromberg Gulf Coast Lithia Springs, Bayou La Batre, Mobile County.
Cherokee Spring, near Citronelle, Mobile County.
Cooks Springs, Cooks Springs, St. Clair County.
Dixie Spring, Dixie Spring, Walker County.
Ingram Lithia Wells, near Ohatchee, Calhoun County.
Livingston Mineral Springs, Livingston, Sumter County.
Luverne Spring, Luverne, Crenshaw County.
MacGregor Spring, Spring Hill, Mobile County.
Matchless Mineral Wells, east of Greenville, Butler County.
Purity Spring, Spring Hill, Mobile County.
Shocco Spring, near Talladega, Talladega County.
White Sulphur Wells, near Jackson, Clarke County.

The following table shows the relative productions, and their respective values, for 1911 and 1912.

Production and value of mineral waters in 1911 and 1912.

	No. of Springs	Quantity Sold (Gallons)	Average Retail Price	Value of Medicinal Waters	Value of Table Waters	Total Value of Mineral Waters	Percentage of Total U. S. Value
1911	10	205,854	$0.15	$20,244	$6,738	$26,982	0.39
1912	16	165,678	0.123	9,610	10,825	20,435	0.30
Increase or decrease	+ 6	+40,176	-----	—10,634	+4,087	—6,547	------
Percentage	------	— 19.52	-----	— 52.53	+60.65	—24.26	------

SAND AND GRAVEL.

THE total production of sand and gravel in the State in 1912 was 852,943 short tons, valued at $268,111, as compared with 677, 894 short tons, valued at $215,413 in 1911, a net increase in quantity of 175,049 short tons, or 25.82 per cent, and an increase of $52,698 or 24.46 per cent in value.

The production of sand was short 11,182 tons from 1911, but the value of the product increased $7,492 or 6.25 per cent. Both the production and the value of gravel increased approximately 50 per cent, which is all the more remarkable when it is noted that chert for road-building was not taken into consideration as in former years.

The following tables give the production, value, and disposition of the sand and gravel produced in 1911 and 1912, and a comparison of the production and value in these years.

Production (in short tons) and value of sand in 1911 and 1912.

	Molding Sand		Building Sand		Paving Sand		Furnace Sand		Engine Sand		Other Sand		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1911	52,766	$19,432	201,214	$70,284	10,975	$3,635	36,540	$7,738	39,520	$11,106	17,883	$7,563	356,293	$119,758
1912	51,107	25,284	205,498	66,586	37,801	14,497	-----	-----	45,000	13,300	15,705	7,083	355,111	127,250
Increase or decrease	—1,659	+5,852	+4,284	—3,698	+26,826	+10,862	-----	-----	+5,480	+2,194	—2,183	— 480	—11,182	+ 7,492
Percentage	— 3.18	+30.11	+ 2.03	— 5.26	+244.43	+298.82	-----	-----	+13.86	+19.75	—12.20	—6.34	— 1.26	+ 6.25

Production of Sand and Gravel in 1911 and 1912.

	Sand		Gravel		Total		Percentage of Total U. S. Value
	Quantity	Value	Quantity	Value	Quantity	Value	
1911	356,293	$119,758	321,601	$95,655	677,894	$215,413	1.018
1912	345,111	127,250	497,832	140,861	852,943	268,111	1.16
Increase or decrease	—11,182	+ 7,492	+176,231	+45,206	+175,049	+52,698	------
Percentage	— 3.14	+ 6.25	+ 54.79	+ 47.25	+ 25.82	+ 24.46	------

STONE.

E. F. BURCHARD.

THE figures presented in the following report have to do with the stone produced and sold by the quarrymen and include only such manufactured product as is put on the market by the quarrymen themselves. This applies especially to rough and dressed building stone, dressed monumental stone, crushed stone, flagstone, curbstone, and paving block. The value given to this manufactured product is the price received by the producer, free on board at point of shipment, and includes therefore the cost of labor necessary to dress the stone. The stone reported as sold rough includes stone sold as rough stock to monumental works, and to cut-stone contractors for building purposes; stone sold as riprap, rubble, and flux; and includes the value of only such labor as is required to get the stone out of the quarry in the shape required by the purchaser. The value given to this stone is the price received by the quarryman free on board at point of shipment. In case the stone is sold to local trade the value is given as the quarryman sells the material, generally at the quarry, but in some cases delivered, if this is done by the producer. In some instances a long haul to market or to the railroad increases the cost of the material, and therefore of the selling price.

PRODUCTION.

C. A. ABELE.

Alabama produces commercially only three kinds of stone, namely, limestone, marble, and sandstone. Of these, the limestone production and value reached the largest proportions, though the value of the limestone produced fell below the figures established in 1910 and 1911. Marble was the only stone whose production showed an increase over that of 1911. The value of the sandstone produced in 1912 was approximately 60 per cent less than the value of the 1911 product.

Below is a table giving the value of the limestone produced in the last five years, from 1908 to 1912, inclusive.

Value of stone production from 1908 to 1912.

Kind	1908	1909	1910	1911	1912
Limestone	$479,780	$700,642	$714,516	$561,798	$531,085
Sandstone	34,099	77,327	109,063	73,195	27,596
Total	513,829	777,969	823,579	634,993	558,681

LIMESTONE.

The most important use of the limestone produced in Alabama in 1912, as in 1911, was blast furnace flux, while riprap, road-making, and crushed stone for concrete follow in the order named. The limestone burned into lime or used in the manufacture of Portland cement is not taken account of here, but is included in the value of each of the finished products in whose manufacture it was used.

As thus limited, the total value of limestone produced in 1912 was $531,085, as compared with $561,748 in 1911, a decrease of $30,713 or 5.46 per cent.

The values of the limestone produced in 1911 and 1912, classified according to the uses of the stone, are given in the following table:

Value of Limestone produced in 1911 and 1912.

Use	1911	1912	Increase or Decrease	Percentage
Paving	$170	$15,700	+ 15,530	—
Riprap	10,459	81,361	+ 70,902	677.90
Roadmaking	37,511	54,270	+ 16,759	44.67
Railroad Ballast	----------	14,093	+ 14,093	—
Concrete	23,077	26,235	+ 3,158	13.68
Flux	468,356	339,166	— 119,190	26.00
Other uses	308	60	— 248	80.88
Total	561,798	531,085	— 30,713	5.46
Percentage of total U. S. value	1.66	1.44	----------	----------

Limestone for Building Purposes.

EUGENE A. SMITH.

From the tables above it will be seen that by far the largest part of the limestone for other purposes than lime burning produced in Alabama 1911-1912, has been for flux rock in the iron furnaces. Crushed stone for road making and riprap follow next, and then dressed building stone.

The preparation of cut stone for building purposes in Alabama, while on the increase, is not yet what it should be. Practically all of this material comes from the quarries in the subcarboniferous limestone of the Tennessee Valley, the most important quarries being at Rockwood in Franklin County, operated by Foster-Creighton-Gould Co., of Nashville. This stone is quite similar in appearance, composition, and other qualities to the Indiana stone, and so far as experience in the use of the stone from the two localities in the buildings of the University of Alabama goes, the Alabama stone holds its own under influence of the weather better than does the Indiana stone. Stone steps, door sills, and window sills, buttress caps, etc., of the Alabama stone put in place in 1885 show practically no deterioration in color and wear under foot, and in crumbling and roughening under the influence of the weather, which cannot be said of some portions of the Indiana stone used in buildings erected in 1909-10. The Rockwood quarries have most modern and approved methods of machinery for sawing the stone and handling it in transit to the mills and elsewhere. The stone is of massive formation, of great thickness and extent. Blocks weighing as much as 25 tons, without crack or flaw, are not infrequently quarried, the size of the blocks being practically limited only by the capacity of the hoisting machinery.

The Oolitic variety is most extensively used for building and monumental work. It is of light gray color, uniform grain, and homogeoneous texture. It possesses a quality of cheapness; it can be cut to any design required, and is at the same time strong and durable.

At the present time the business at this quarry is confined to the furnishing of rough and sawed stone to the cut stone contractor or dealer.

With the installing of adequate machinery at the quarry for doing the finished work, there should never be any longer any reason for going outside of the State for this quality of stone. Already the material has been very extensively used in public buildings in Mississippi, Tennessee, as well as in Alabama. The only reason why it was not used in the recently erected buildings at the University of Alabama was that at the time these building contracts were let, the quarries furnished only the rough sawn stone and there was not in Alabama any establishment adequately equipped for the dressing of the stone in the quantity needed.

MARBLE.

EUGENE A. SMITH.

The marble of Alabama is of two kinds, crystalline or true marble and non-crystalline.

The crystalline or statuary marble occurs mainly in a narrow valley along the western border of the metamorphic area, extending from Marble Valley in Coosa County, through Talladega into Calhoun. The length of the marble belt through Coosa and Talladega counties is about 50 miles. The width of the valley carrying the marble as a rule is from one quarter to one-half mile, widening in places to a mile and a quarter, for example in the neighborhood of Sylacauga.

The quarries longest known are Gantt's and Herd's near Sylacauga, Nix's near Sycamore, and Taylor's and McKenzie's near Taylor's Mill East of Talladega. From all these marble was quarried before the civil war.

During 1912, only 3 establishments had reported any marble production, viz.: The Alabama Marble Co., at Gantt's Quarry near Sylacauga, the Alabama-Carara Marble Co., near Talladega, and the Moretti-Harrah Marble Co., Sylacauga. Two other companies, however, have made some rather extensive developments and will no doubt report some production later. These are the Eureka Marble Co. (Bishop's) near Talladega Springs; the Alabama Marble Quarries of the Scott Brothers, near Sycamore.

The plant of the Alabama Marble Company at Gantt's Quarry was destroyed by fire in December, 1910, and it was not until the middle of August, 1911, that the rebuilding was completed and production begun.

I think it is fairly safe to say that on the whole the marble from this quarry and immediate vicinity is of the highest grade of commercial white marble now on the market and obtainable in large quantity. There are small quantities of marble produced both in Italy and Vermont that are somewhat freer from coloring matter than the best grades that can be produced in Alabama in any quantity. But on the other hand, the poorest grades in Alabama greatly surpass the poorest grades produced elsewhere, so that the average of the Alabama deposit is probably somewhat higher than that of any other so far developed, not excluding even the marble from the Carara district in Italy. The marble from this State (Gantt's Quarry) has now a well established reputation and has been used in more than 150 important buildings throughout the United States.

It can be seen in the galleries of the National Museum in Washington.

A beautiful quality of variegated limestone or marble—red, pink and white—belonging probably to the Cambrian formation, occurs in Shelby County a mile or two south of Shelby Springs station on the L. & N. railroad, and extending thence southwest for a mile or two. Nothing but prospecting work has been done on this marble. The Trenton limestone in the Appalachian valleys, particularly Jones Valley below Bessemer, contains marble similar to that quarried in the vicinity of Knoxville, Tenn. Also at Pratt's ferry on the Cahaba River in Bibb County a quarry was for many years worked in this formation and turned out a very beautiful quality of marble varying in color from gray through pink, red and brown shades.

A black marble which is exceedingly promising, has been reported and some development work done near Anniston, and at Piedmont, Calhoun County, and some very handsome specimens of cave onyx have been obtained from near Kymulga in Talladega County.

In the Coastal Plain the St. Stephens limestone of the Tertiary holds ledges of hard, almost crystalline rock capable of taking good polish. The colors vary from nearly white, through shades of yellowish into red, and it would make a handsome decorative marble, especially for inside work.

Other limestone formations, such as the Subcarboniferous and the Knox Dolomite, could in places be drawn upon for marble.

It is possible to publish only the total value of the marble produced in the State in 1912, since a classification of the product according to its uses would necessitate the publication of confidential figures. The total value of the marble produced, the product of three operators, was $283,619 or 3.64 per cent of the total United States value.

The greater portion of the product was used for interior decoration.

SANDSTONE.

The production of sandstone in 1912 suffered a decline of nearly 60 per cent from that of 1911. In fact, so great was the decrease in the production of this stone that it is possible to publish only the total value of the stone produced in order not to divulge figures of single producers given the Survey in confidence.

Rubble, riprap, and crushed stone, and also an insignificant amount of ganister were produced, but in no case did the 1912 production equal that of 1911, the decrease ranging from 34 per cent to 99 per cent.

The total value of the 1913 production was $27,596 as compared with $73,195 in 1911, or a decrease of $42,599 or 58.20 per cent.

SUMMARY.

BECAUSE of the difference in the units of measurement employed in the various branches of the mineral industry, a summation of the production of the year can include only the values of the products. It is also to be noted that a simple summation of all the values of the minerals or mineral products listed in this pamphlet would give a value much in excess of the true value, since in many cases, as, for instance, coal and coke, and iron ore and pig iron and steel, the second product is directly a product of the first, and the value of the first is included in that of the second. To give the values of both as a part of the total would be to repeat, in a measure, at least a partial value of the first or raw product, and would give an erroneous result.

As the Survey has not however, the figures upon which to base an estimate as to the percentage of each product which was used in the manufacture of some other product, the summation of the mineral production of the State, as given here, will be a simple summation of the values reached by the individual branches of the industry.

According to this rather unsatisfactory manner of summation, which does not include the value of the steel produced, the value of the 1912 mineral production and ultimate products was $60,141,793, as compared with $52,772,951 in 1911, an increase of $7,368,842 or 13.96 per cent. This value was still, however, lower than that of 1910 by $3,066,152 or 4.86 per cent.

In 1912 pig iron was the most valuable product, the others being in the order of their value, coal, coke, iron ore, clay products, cement, limestone, lime, sand and gravel, marble, and miscellaneous, including bauxite, clay, sandstone, graphite, mineral waters, gold and silver, mica, and abrasives.

Below is a tabular presentation of the value of the mineral productions of 1910, 1911 and 1912.

Total value of the mineral production and products in Alabama in 1910, 1911, and 1912.

Year.	Value.
1910	$63,207,945
1911	52,772,951
1912	60,141,793

A far truer conception of the relative production of 1910, 1911, and 1912 may be obtained by taking the production returns of each branch of the industry, irrespective of the varieties of units of measurement used, forming a percentage for 1911 and 1912 based on the production of 1910, weighting this percentage by the value of the output, thus preparing an index number of each branch.

Proceeding in this manner, the following results are deduced:

Percentage of the production of mineral products (raw and finished) in 1911 and 1912, using the production of 1910 as a base.

Year.	Percentage.
1910	100.0
1911	88.6
1912	84.4

PROBABLE FUTURE PRODUCTION.

The following minerals have been produced in Alabama in past years, but no production was reported for 1912; Fuller's Earth, Manganese Ore, Pyrite, Mineral Paints, Petroleum, Phosphate Rock, and Quartz. Since all these are known to occur in some quantity and of a quality to make them of commercial value, the production may be resumed at any time.

Among the probable productions in the near future, are natural gas and petroleum, onyx marble, turquoise and other minerals noticed in the Index to the Mineral Resources of Alabama a publication of the State Geological Survey.

Natural gas under pressure of 630 pounds has been obtained from several wells in Fayette and Walker Counties, and smaller quantities under less pressure have been obtained near Huntsville and elsewhere.

A Report with map on the Fayette County Gas Field has been published by the survey during the year. No commercial production has yet been reported.

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GEOLOGICAL SURVEY OF ALABAMA

EUGENE ALLEN SMITH, *State Geologist*

BULLETIN No. 15.

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1913

COMPILED FROM MINERAL RESOURCES OF THE UNITED STATES

By
CHARLES ARTHUR ABELE

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UNIVERSITY, ALABAMA
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PRESS
BROWN PRINTING CO.
MONTGOMERY
ALABAMA

LETTER OF TRANSMITTAL.

UNIVERSITY, ALA., December, 1914.

HON. EMMET O'NEAL,

Governor of Alabama,

Montgomery, Ala.

SIR:—I have the honor to transmit herewith the manuscript of a Report on the Mineral Production of Alabama for the year 1913, with the request that it be printed as Bulletin No. 15 of the Geological Survey of Alabama.

Very respectfully,

EUGENE A. SMITH,

State Geologist.

GEOLOGICAL CORPS.

Eugene Allen Smith, Ph. D.	State Geologist
William F. Prouty, Ph. D.	Chief Assistant
S. J. Lloyd, Ph. D.	Assistant
Robert S. Hodges	Chemist
Herbert H. Smith	Curator of Museum
Roland M. Harper, Ph. D.	Botanist
George N. Brewer	Field Assistant
A. T. Donoho	Stenographer

RIVER GAGE HEIGHT OBSERVERS.

C. J. Stowe	Jackson's Gap, Tallapoosa River
J. E. Whitehead	Riverside, Coosa River
S. T. Willard	Beck, Conecuh River
Ed. Bullen	Red Bay, Big Bear Creek
E. Cummings	Wedowee, Little Tallapoosa River

From the records of daily observations of the gage readings at these places when extended through sufficient time, the calculations of available horsepower to be obtained from the different streams is made.

TABLE OF CONTENTS.

PREFACE.

The statistics of all the minerals included in the following pages have been collected in cooperation with the United States Geological Survey, and have been compiled from advance chapters of the *Mineral Resources of the United States*, a publication of the Federal Survey.

The introductory and general matter in each of these articles has either been taken without change from the U. S. advance chapters or has been rearranged or condensed from these chapters, or entirely rewritten to suit it for our present purposes. In each case credit is given to the author.

INTRODUCTION.

By E. W. Parker, Statistician, U. S. G. S.

WITH iron ore considered as the basis of iron production, Alabama ranks eighteenth among all the States in the value of its mineral products, and second among the States south of Mason and Dixon's line and Ohio River. If pig iron were taken as the basis of iron production, Alabama would rank about fifteenth among all the States, but would maintain the position it now holds among the Southern States. West Virginia, with its great production of mineral fuel—coal, petroleum, and natural gas—is the premier mineral producer among the Southern States. Alabama is not distinguished as the leading producer in any important mineral substance, but it ranks third in the production of iron ore, fifth in the production of pig iron, second in quantity and third in value in the production of coke, and sixth in quantity and fifth in value as a producer of coal. Considerable progress has been made in the development of the clay-working and quarrying industries, but these resources have not been exploited to the same extent as those of coal and iron.

The rise of Alabama as a mining and industrial Commonwealth had its beginning in the last quarter of the nineteenth century following the development in 1882 of the extensive deposits of iron ore in the vicinity of Birmingham and contiguous to the already partially known and developed coal fields. The boom and speculative fever which followed was one of the most spectacular incidents in the industrial development of the United States, paralleled only by the rushes which followed Marshall's discovery of gold in California, the exploitation of the Comstock lode in Nevada, and the later rush to the Alaskan gold fields. The speculative fever reached its climax in 1885, and was followed by a period of relapse and liquidation which lasted two years. There was beneath the Birmingham craze, however a substantial foundation for legitimate industrial development, and after the bursting of the original bubble there

has followed more than a quarter of a century of steady healthful growth. The iron ores of Alabama, while inferior to those of Lake Superior, have a compensating advantage in the deposits of good coking coal, and of the limestone requisite for fluxing in the immediate vicinity, as the result of which Birmingham, the Pittsburgh of the South, can manufacture pig iron cheaper than any other district in the world. The iron ores are principally non-Bessemer hematites, and steel is produced chiefly by the open-hearth process. Prior to 1882 when the boom began, the coal production of Alabama had not amounted to as much as half a million tons in any one year. In 1885 it was nearly 2,500,000 tons, but in the collapse of 1886 that followed it decreased to 1,800,000. Since 1886 it has shown an almost unbroken series of annual increases in the production and reached its maximum of 17,678,522 tons in 1913, an increase of more than 1,500,000 tons over 1912, and exceeded, by approximately the same quantity, the previous maximum record made in 1910. The value of the coal product of Alabama is approximately two-thirds that of the total mineral output, and amounted in 1913 to $23,083,724.

In 1882 Alabama produced about 100,000 long tons of pig iron. In 1913 the marketed production of pig iron in Alabama amounted to 1,924,762 long tons, valued at $23,242.374, a slight decrease in quantity from 1912 and an increase in value of nearly $2,000,000. The value of the pig iron produced in Alabama in both 1912 and 1913 was slightly in excess of the value of the coal mined. Although the production of pig iron in 1913 was less than in 1912, there was an increase in the production of iron ore from 4,776,545 tons in 1912, valued at $5,734,371, to 5,333,218 long tons, valued at $6,648,569, in 1913. The value of this iron-ore production, not the value of the pig iron, is used in making up the total value of the mineral products of the State.

The coke production of Alabama increased from 2,975,489 short tons, valued at $8,098,412, in 1912 to 3,323,664 short tons, valued at $9,627,170, in 1913. The increase in the production of iron ore and in the manufacture of coke with the decreased sales of pig iron, indicate that some of the ore and of the coke was sent to furnaces outside of the State, although in addition to the actual marketed production of pig iron there was an

increase in stock carried over to January 1, 1914, as compared with stocks on hand January 1, 1913.

The total value of the mineral production of Alabama, exclusive of the value of the pig iron and including the value of the iron ores, was $34,660,545 in 1913, compared with $30,641,983 in 1912, of which, as already stated, approximately two-thirds is represented by the output of the coal mines. Nearly one-fifth of the total value was contributed by the iron mines. The increase in 1913 over 1912 was $4,018,562, or 13 per cent. The principal coal-producing counties are Jefferson, Walker, Bibb, and Tuscaloosa in the order named. The principal iron ore counties are Jefferson, Tuscaloosa, Etowah and Franklin. The iron-making industry is centered in Birmingham and vicinity. The combined value of the pig iron and coke made in Alabama approximates $33,000,000. These values are not included in the total as they are represented in the value of the iron ore and the coal produced. The clay-working industries yielded products in 1913 valued at $2,091,581, against $1,935,179 in 1912, the principal part of which is from the manufacture of common brick. This does not include the value of raw clay sold, which in 1913 amounted to $53,419. The center of the clay-working industry is in Jefferson County, and Birmingham furnishes the principal market. Vitrified, front, and fire brick represent a value approximating that of common brick alone, and the total output of the brickyards makes up nearly 80 per cent of the State's total clay products. All of the fire brick produced in the State is reported from Jefferson County and all of the vitrified brick is from Jefferson and St. Clair counties. Clay pits for the manufacture of common brick have been opened in one or more places in 38 different counties. The quarry products, the larger part of which is limestone, were valued in 1913 at $1,285,944, an increase of more than 50 per cent from $842,300 in 1912. The increased production in 1913 was in the output of limestone for flux and concrete work, sandstone for use in Government improvements on Warrior River, and the production of marble. Two-thirds of the total value of the stone production is limestone. The most important use of the limestone is for blast furnace flux, with riprap, road making, and crushed stone following in the order named. Little of the Alabama limestone is used for

building at the present time, but in the opinion of Dr. Eugene A. Smith this use is on the increase and is due to the development of an oolitic limestone similar in appearance and composition to the Indiana stone. This stone is of light-gray color, uniform grain, and homogeneous texture. It possesses the quality of cheapness and can be cut to any design required. Marble holds second place in the value of the quarry products, a beautiful white marble occurring in Coosa and Talladega counties being used extensively for building, and black marble which gives promise of future development has been prospected near Anniston. The cement production of Alabama amounted in 1913 to 823,246 barrels, valued at $685,422, against 726,688 barrels, valued at $608,620, in 1912. The lime production is not included in that of the limestone, and amounted to 75,468 short tons, valued at $290,394 in 1913, a decrease from 79,957 short tons, valued at $297,178, in 1912. Alabama produces a small quantity of gold and silver, and other minor products are bauxite, graphite, mica, millstones, mineral paints (natural pigments), mineral waters, natural gas, and sand and gravel.

In the following table is presented a comparison of the mineral output of Alabama in 1912 and 1913. As stated above, the total does not include the value of pig iron nor that of coke, but it does include the value of the coal made into coke and of the iron ore sold or used:

Mineral production of Alabama in 1912 and 1913.

PRODUCT	1912				1913			
	Raw		Derived		Raw		Derived	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Bauxite long tons	14,178	$60,254			(*)	(*)		
Cement, barrels			726,688	$608,620			828,246	$685,422
Clay products, short tons	48,052	†88,414		1,985,179	49,901	†$58,419		2,091,581
Coal, short tons	16,100,600	20,829,252			17,678,522	28,083,724		
Coke, short tons			2,975,489	†8,098,412			3,323,664	†9,627,170
Gold, fine ounces (troy)			809	16,724			537	11,094
Graphite, crystalline, pounds	(*)	(*)			2,020,910	87,386		
Iron ore, long tons	4,776,545	5,734,871			5,388,218	6,648,569		
Iron, pig, long tons			1,987,758	†21,371,058			1,924,762	† 28,242,374
Lime, short tons			79,957	297,178			75,468	290,394
Mica								(*)
Millstones				(*)				(*)
Mineral paints, natural pigments, short tons							(*)	(*)
Mineral waters, gallons sold	165,678	20,435			169,687	19,343		
Natural gas		(*)				(*)		
Sand and gravel, short tons	852,943	268,111			1,405,068	398,088		
Silver, fine ounces (troy)			168	108			117	71
Stone		(‡)		‡842,800		(‡)		‡ 1,285,944
Miscellaneous		(‡)		‡29,456		46,618		12,861
Total value, eliminating duplications	$30,641,983				$34,660,545			

*Value included under "Miscellaneous." †Value not included in total value. ‡Raw product included under derived product.

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1913.

ABRASIVES.

EUGENE A. SMITH.

ALABAMA'S production of abrasives is at present limited to a small number of millstones quarried and made at Dutton, Jackson County; there are, however, several materials in different parts of the State which are sufficiently promising to be worth investigation and thorough testing; the nature and locality of these deposits were treated in Bulletin No. 13, which see.

BARYTES.

So far as known, no barytes has been produced from Alabama mines since 1906. There are some deposits which probably could be worked in Calhoun, Etowah, and St. Clair Counties, in the northeastern part of the State, and in Bibb County, near the center. The residual deposits so far worked are associated with the Chickamauga ("Pelham") limestone, of Ordovician age, and the Knox dolomite, of Cambrian and Ordovician age. They seem to be localized along lines of folding and faulting of the rocks, particularly along the eastern side of the Appalachian fold. The barytes probably occured originally as veins and replacements along fissured or fractured dolomite. Solution of the dolomite has left the insoluble barium sulphate in nodules and bowlders in the residual clay.

BAUXITE.

The production of bauxite in Alabama for 1913 was limited to one producer, which accounts for the decrease and also for the joining of the Alabama and Georgia totals.

The following table gives the production and value of bauxite from 1889 to 1913, inclusive:

Production of bauxite in the United States, 1889-1913, by States, in long tons.

<table>
<tr><th>Year</th><th>Georgia</th><th>Alabama</th><th>Arkansas</th><th>Total</th><th>Value</th></tr>
<tr><td>1889</td><td>728</td><td>........</td><td>........</td><td>728</td><td>$2,366</td></tr>
<tr><td>1890</td><td>1,844</td><td>........</td><td>........</td><td>1,844</td><td>6,012</td></tr>
<tr><td>1891</td><td>3,301</td><td>292</td><td>........</td><td>3,593</td><td>11,675</td></tr>
<tr><td>1892</td><td>5,110</td><td>5,408</td><td>........</td><td>10,518</td><td>34,183</td></tr>
<tr><td>1893</td><td>2,415</td><td>6,764</td><td>........</td><td>9,179</td><td>29,507</td></tr>
<tr><td>1894</td><td>2,050</td><td>9,016</td><td>........</td><td>11,066</td><td>35,818</td></tr>
<tr><td>1895</td><td>3,756</td><td>13,313</td><td>........</td><td>17,069</td><td>44,000</td></tr>
<tr><td>1896</td><td>7,313</td><td>11,051</td><td>........</td><td>18,364</td><td>47,338</td></tr>
<tr><td>1897</td><td>7,507</td><td>13,083</td><td>........</td><td>20,590</td><td>57,652</td></tr>
<tr><td>1898</td><td>........</td><td>........</td><td>........</td><td>25,149</td><td>75,437</td></tr>
<tr><td>1899</td><td>15,736</td><td>14,499</td><td>5,045</td><td>35,280</td><td>125,598</td></tr>
<tr><td>1900</td><td colspan="2">19,739</td><td>8,445</td><td>28,184</td><td>89,676</td></tr>
<tr><td>1901</td><td colspan="2">18,038</td><td>867</td><td>18,905</td><td>79,914</td></tr>
<tr><td>1902</td><td colspan="2">22,677</td><td>4,645</td><td>27,322</td><td>120,366</td></tr>
<tr><td>1903</td><td colspan="2">22,374</td><td>25,713</td><td>48,087</td><td>171,306</td></tr>
<tr><td>1904</td><td colspan="2">21,913</td><td>25,748</td><td>47,661</td><td>235,704</td></tr>
<tr><td>1905</td><td colspan="2">15,173</td><td>32,956</td><td>48,129</td><td>240,292</td></tr>
<tr><td>1906</td><td colspan="2">25,065</td><td>50,267</td><td>75,332</td><td>368,311</td></tr>
<tr><td>1907</td><td colspan="2">........</td><td>........</td><td>*97,776</td><td>480,330</td></tr>
<tr><td>1908</td><td colspan="2">14,464</td><td>*37,703</td><td>52,167</td><td>263,968</td></tr>
<tr><td>1909</td><td colspan="2">22,227</td><td>*106,874</td><td>129,101</td><td>679,447</td></tr>
<tr><td>1910</td><td colspan="2">33,096</td><td>*115,886</td><td>148,982</td><td>716,258</td></tr>
<tr><td>1911</td><td colspan="2">30,170</td><td>*125,448</td><td>155,618</td><td>750,649</td></tr>
<tr><td>1912</td><td>19,587</td><td>14,173</td><td>*126,105</td><td>159,865</td><td>768,932</td></tr>
<tr><td>1913</td><td colspan="2">27,409</td><td>*182,832</td><td>210,241</td><td>997,698</td></tr>
</table>

*Production of Tennessee included.

For an outline of the uses of bauxite, see Bulletin No. 13.

CEMENT.

EUGENE A. SMITH.
E. F. BURCHARD.

PUZZOLAN OR SLAG CEMENT.

DURING the past six years only one establishment in Alabama has been engaged in the manufacture of slag cement, using the material from the furnaces about Birmingham. The production is included in the returns for Portland cement and cannot be given separately.

PORTLAND CEMENT.

RESOURCES.

Alabama contains large supplies of limestone, chalk, clay and shale well adapted for Portland Cement manufacture, and widely distributed throughout the State. Coal and labor are abundant and cheap, transportation facilities are excellent, and many of the best limestone and chalk localities are situated on navigable rivers, giving ready access and cheap water transportation to Galveston, New Orleans, Mobile, Charleston, and other ports of the Gulf and Atlantic Coasts. This advantage of location will be immensely increased with the opening of the Panama Canal for cement plants located in Alabama will be more than a thousand miles nearer to the Isthmus than their nearest possible competitors

The limestones and shales of the northern part of the State lie so close to each other, and above all so close to the great coal mines which must supply the fuel, that the establishment of Portland Cement plants near the coal mines would give to this industry in Alabama the same advantages which the proximity of the iron ore, the coal, and the stone has given to the iron industry, and which has placed our State beyond competition.

As a Portland cement mixture, ready for burning, consists approximately of 75 per cent. lime carbonate and 25 per cent. of clayey matter, the material furnishing the lime carbonate is necessarily of more economic importance than that from which the silica and alumina are derived. In consequence, a Portland cement plant is usually located in the immediate vicinity of a suitable limestone, while the clay or shale required to complete the mixture may be brought some distance.

The limestone formations in North Alabama which can supply the stone adapted for use in cement manufacture are the Trenton or Pelham limestone and the Bangor or Subcarboniferous. In close proximity to both these limestone formations are the shales of the Clinton, Subcarboniferous and Coal Measures.

At the present time there are two cement plants in North Alabama, namely, the Standard Portland Cement Co., located at Leeds in Jefferson County, and the Atlantic & Gulf Portland Cement Co., located at Ragland in St. Clair County. Both of these plants make use of the hard Trenton limestone, and the Standard Cement Co., according to Burchard of the U. S. Geological Survey, uses the shale of the Clinton formation whilst the Ragland Company makes use of the shales of the Coal Measures. Up to the present time no establishment is utilizing the Bangor limestone.

In Middle Alabama the soft, chalky Cretaceous limestone of the Selma Chalk, is the material utilized by the Alabama Portland Cement Co., at Spocari, near Demopolis. The same Company makes use of residual clays overlying and derived from the weathering of the Selma Chalk. During 1913 there was no production reported from the Demopolis plant.

In Southern Alabama the St. Stephens limestone outcropping east and west across the State, furnishes excellent material for Portland Cement manufacture, using either residual clays from decomposition of the limestone, or the clays of the Grand Gulf formation which are almost everywhere in close proximity to the limestone.

The following table summarizes the number of active plants in the United States, and the production of puzzolan cement during the last five years:

Statistics of the puzzolan cement industry, 1909-1913.

	1909	1910	1911	1912	1913
Number of plants reporting production:					
Alabama	1	1	1	1	1
New York*	....	....	1	1	1
Ohio	2	2	1	1	1
Pennsylvania	1	1	1	1	1
Total	4	4	4	4	4
Production in barrels of 380 pounds	160,646	95,951	93,280	91,864	107,313
Value of production	$99,453	$63,286	$77,786	$77,363	$97,663

*Includes production of Collos cement in 1911, 1912, and 1913.

Owing to the fact that there was in Alabama in 1913 only one producer of puzzolan cement, and not more than two operating plants in the Portland cement industry, it is necessary to combine the productions of both industries in order to avoid publishing figures which were given the Survey in confidence. The tabular results of such a combination are, however, necessarily inconsistent and not to be taken too literally, since the weights per barrel of the two kinds of cement vary.

The total quantity of Portland and puzzolan cement produced in Alabama in 1913 was 823,246 barrels, valued at $685,422 as compared with 726,688 barrels in 1912, valued at $608,620, or an increase in the production of 96,588 barrels, or 13.3 per cent, giving an increase in value of $76,802, or 12.6 per cent.

The percentages of increase in quantity and value are notably less than in 1912.

Below are presented in tabular form the foregoing figures.

Production and value of cement (including puzzolan and Portland) in Alabama in 1912 and 1913.

	No. of Producers	Quantity (Bbls.	Value	Percentage of total U. S. Value
1912	3	726,688	$608,620	0.91
1913	3	823,246	685,422	0.74
Increase	....	96,558	76,802	....
Percentage increase	....	13.3	12.6	....

CLAY AND CLAY PRODUCTS.

JEFFERSON MIDDLETON AND EUGENE A. SMITH.

CLAY.

CLAY available for the manufacture of clay products is one of the most widely spread of our minerals. Clay miners are usually also the manufacturers of the lower-grade clays, but as the higher grades of ware are reached, the rule is that fewer and fewer manufacturers are also miners, until in the highest grades of ware the rule is that the manufacturer is not the miner of the clays that he uses. The figures given in the following tables represent clay that is mined and not manufactured by the miner, but is sold as clay. The clay thus sold is small in quantity compared with that consumed and includes mainly clay used for refractory products.

The total quantity of clay mined in Alabama and sold as such in 1913 was 49,901 short tons, valued at $53,419. This was an increase in quantity of 6,849 tons, or 15.91 per cent, and of $20,005, or 59.87 per cent in value over 1912. While some miscellaneous clay was produced in 1913, fire clay was the only kind of which the figures of production are available for publication.

Below is a table giving the production and value of clay mined and sold in Alabama from 1909 to 1913 inclusive, and a comparison of the production of 1912 and 1913.

Production of clay in Alabama from 1908 to 1913 inclusive, and a comparison of the production in 1912 and 1913.

YEAR	Fire Clay		Miscellaneous Clay		Total	
	Quantity Short Tons	Value	Quantity Short Tons	Value	Quantity Short Tons	Value
1908	68,289	$48,983	24,000	$12,000	92,289	$60,983
1909	45,137	35,345	18,271	5,587	63,408	40,932
1910	54,482	32,395	20,600	5,650	75,082	38,045
1911	35,208	29,909	....	....	35,208	29,909
1912	38,552	31,414	4,500	2,000	43,052	33,414
1913	49,901	53,269	*	*	49,901	53,419
Increase 1913	11,049	21,855	....	....	6,849	20,005
Percentage of Increase	28.66	69.56	....	....	15.91	59.87

*Not divulged but included in total.

In 1912 the average value of fire clay was $0.81 per short ton and the fire clay production of Alabama represented 1.33 of the total value of the United States production. In 1913 the average value of Alabama fire clay was $1.07 per short ton, and the value of the Alabama product was 2.06 per cent of the total value of the fire clay produced in the United States.

CLAY WORKING INDUSTRIES.

ALABAMA is rich in clays, but its rank as a clay-working State is not high. In 1913 it was sixteenth among the States, with products valued at $2,091,581, or 1.15 per cent of the total for the country. This was an increase over 1912 of $156,402, or 8.08 per cent. In 1913 Alabama was ninth in the production and value of vitrified brick, and ninth in production and eleventh in value of fire brick. The principal product is common brick, valued in 1913 at $730,148, and representing 34.91 per cent of the value of all of Alabama's clay products in that year. Front brick, fireproofing, and tile, not drain, were reported to the value of $258,130, so that the structural materials represent nearly one-half of Alabama's clay products in 1913. The engineering products, vitrified paving brick, draintile, sewer pipe, and fire brick were reported to the value of $1,057,059, or more than 50 per cent of the total. Pottery clays are abundant in the State, but this branch of the industry has not been developed extensively, the value of pottery production in 1913, being only $20,158.

Jefferson County is the principal clay-working county, reporting a production valued at $1,313,432, or 62.8 per cent of the total value for 1913, an increase of $178,093 over 1912. No pottery was reported from this county. All of the fire brick produced in the State comes from Jefferson County, and fire brick is its principal product. Vitrified brick was reported only from Jefferson and St. Clair counties, the former being the leading county with 22,710,000 brick, valued at $339,615. The leading counties in the value of common brick in 1913 were, in the order of their importance, Montgomery, Talladega and Jefferson.

Clay products of Alabama, 1909-1913.

Product	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	146,180,000	135,785,000	129,694,000	136,989,000	130,928,000
Value	$799,693	$746,961	$708,903	$759,409	$730,148
Average per M	$5.47	$5.50	$5.47	$5.54	$5.58
Vitrified—					
Quantity	20,444,000	19,772,000	21,444,000	26,480,000	24,183,000
Value	$262,376	$236,516	$246,707	$353,308	$361,722
Average per M	$12.83	$11.96	$11.50	$13.34	$14.96
Front—					
Quantity	(*)	(*)	9,169,000	10,629,000	(*)
Value	(*)	(*)	$128,403	$132,033	(*)
Average per M	$16.19	$15.96	$14.00	$12.42	$15.29
Fancy, value	(*)	....	(*)	(*)	....
Fire, value	$196,887	$163,672	$193,375	$240,434	(*)
Draintile, value	(*)	$3,773	$3,777	$5,465	$10,302
Sewer pipe, value	(*)	(*)	(*)	(*)	(*)
Fireproofing, value	(*)	(*)	(*)	(*)	(*)
Tile, not drain, value	....	....	....	....	(*)
Pottery:					
Red earthenware, value	$11,886	$8,475	$11,243	$10,990	$11,164
Stoneware and yellow and Rockingham ware, value	$24,453	$16,871	*$14,753	$11,228	$8,994
Miscellaneous, value	$404,832	$496,791	$639,941	$422,322	$968,751
Total value	$1,700,127	$1,667,559	$1,947,102	$1,935,179	$2,091,581
Number of active firms reporting	100	87	82	74	68
Rank of State	22	22	17	17	16

*Included in "Miscellaneous."

BRICK AND TILE.

THE total production of common brick in Alabama in 1913 was 130,923 M, valued at $730,148. This, as compared with the 1912 production, represents a decrease in both quantity and value, of 6,066 M, or 4.43 per cent, and of $29,261 or 3.85 per cent.

In the case of vitrified brick there was a decrease in quantity of 2,297 M, or 8.67 per cent. but an increase in value of $8,419, or 2.38 per cent. The other kinds of brick, including front, fire, fancy, sewer pipe, fire proofing and silica brick (produced by less than three manufacturers, and individual production therefore not available for publication), show an increase in value of $73,962, or 8.26 per cent.

The following tables give a review of the brick and tile industry in Alabama for 1912 and 1913:

Production of brick and tile in Alabama in 1913, not including pottery products.

Kind	Quantity per Thousand	Value	Average Value per Thousand	Percentage of total value of brick and tile	Percentage of total U. S. value
Common brick	130,923	$730,148	$5.58	35.25	1.46
Vitrified Brick	24,183	361,722	14.96	17.46	2.98
Drain Tile	....	10,802	....	0.52	0.12
Miscellaneous	....	*968,751	....	46.77	....
Total	....	$2,071,423	....	100.00	1.97

*Includes front brick, fire brick, fancy brick, sewer pipe, fire-proofing, and silica brick.

Brick and tile production in 1912 and 1913 compared.

Kind	1912			1913			Increase or Decrease in Value	Percentage
	Quantity M	Value	Average Price	Quantity M	Value	Average Price		
Common Brick	136,989	$759,409	$5.54	130,923	$730,148	$5.58	—$29,261	3.85
Vitrified Brick	26,480	353,303	13.34	24,183	361,722	14.96	+ †8,419	2.38
Front Brick	10,629	132,033	12.42	*	*	15.29	....	....
Fire Brick	....	240,434	....	*	....	....	....	....
Drain Tile	....	5,465	....	....	10,802	....	+ †5,337	97.66
Miscellaneous	....	*422,322	....	....	†968,751	....	....	....

*Includes fancy brick, sewer pipe, fire proofing, and silica brick.

†Includes front brick, fire brick, fancy brick, sewer pipe, fire proofing, and silica brick.

POTTERIES.

THE pottery industry of Alabama is of relatively small importance, as only the commoner and coarser grades of ware are produced, and most of this for local trade only.

Production was reported for 1913 by 9 operators, a decrease of 6. The output was valued at $20,158, a decrease of $2,055, or 9.25 per cent. The products consisted of red earthen ware and stone ware only. There were five idle potteries in Alabama in 1913. The rank of Alabama in this industry for 1913 is 18.

The following tables show the values of pottery product in 1913 and a comparison of the production and values for the years 1912 and 1913:

Value of pottery products in 1913.

Kind	Value	Percentage of total Alabama Pottery's Products	Percentage of total U. S. Value
Red Earthenware	$11,164	55.40	1.12
Stoneware and Rockingham ware	8,994	44.60	0.24
Total	20,158	100.00	.05

Comparison of pottery products in 1912 and 1913.

Kind	1912	1913	Increase or Decrease	Percentage
Red Earthenware	$10,990	$11,164	+$ 174	1.58
Stoneware and Rockingham ware	11,228	8,994	— 2,229	19.87
Total	22,218	20,158	— 2,055	9.25

COAL.

E. W. PARKER.

INTRODUCTORY.

THE great Appalachian coal region which furnishes over two-thirds of the coal production of the United States and which extends from Ohio and Pennsylvania on the north in a gradually narrowing belt through eastern Kentucky and Tennessee has its southern terminus in a considerably broadened area that occupies a large part of the northern half of Alabama. The coal-bearing formations of Alabama underlie about 8,400 square miles and are divided into four distinct basins, the Coosa, the Cahaba, and the Warrior, named from the rivers which drain them, and the Plateau, which includes Blount, Lookout, and Sand or Raccoon Mountains. By far the most important basin in area and in production in the Warrior, which includes all of Walker County, most of Jefferson, Tuscaloosa, and Fayette counties, and smaller parts of Blount, Cullman, Winston, and Marion counties. The area known to contain coal is approximately 4,000 square miles, or one-half the total coal area of the State, and contributes about 80 per cent of the total production.

There are several distinct coal groups in the basin, the most important of which are the Brookwood, the Pratt, and the Mary Lee, designated by the names of their principal beds. The Mary Lee group includes the Blue Creek, the Jagger, and the Newcastle beds, most of which are mined in places. The Brookwood, the Pratt, and the Mary Lee produce most of the coking coal mined in the State, and more than half of all of the coal mined in the district.

The Cahaba Basin, second in importance, is a long narrow syncline, 68 miles long and about 6 miles wide, southeast of the Warrior, and occupies parts of St. Clair, Jefferson, Shelby, and Bibb counties. There are many workable beds, and the total quantity of coal in the basin is large. The production is something over 10 per cent of the total for the State.

The Coosa Basin is a deep syncline east of the Cahaba and parallel with it, extending across Shelby and St. Clair counties. It is also long and narrow, 60 miles long by 6 miles wide. It has not been thoroughly explored, but in different parts of the area from two to twelve beds, 3 or more feet in thickness, have been reported.

The Plateau field embraces parts of Blount, Etowah, DeKalb, Cherokee, Marshall, and Jackson counties, and although it has an area underlain by coal four times that of the Cahaba and the Coosa combined, the resources in Alabama are comparatively small. There are four to six beds locally workable.

So far as known, the earliest record of the existence of coal in Alabama was made in 1834. The first statement of production in the State is contained in the United States census report for 1840, in which year the production is given as 946 tons. The census report for 1850 does not mention any coal production for the State, and the next authentic record is contained in the census statistics of 1860, when Alabama is credited with an output of 10,200 short tons. The mines of Alabama were probably worked to a considerable extent during the Civil War, but there are no records of the actual production until 1870, for which year the United States census reports a production of 11,000 tons. Ten years later the production had increased to 323,972 short tons, but the development of the present great industry really began in 1881 and 1882, when attention was directed to the large iron deposits near the city of Birmingham and thus the great "boom" of that city and vicinity was inaugurated. By 1885 the coal production of the State had increased to nearly 2,500,000 tons. Then followed a period of relapse and liquidation, which lasted two years, after which business settled down to a conservative and rational basis and has since developed steadily. In 1902 the coal production of the State reached a total of more than 10,000,000 tons, and reached the maximum of 17,678,522 tons in 1913.

PRODUCTION.

Total production in 1913, 17,678,522 short tons; spot value, $23,083,724.

The increase in coal production in Alabama in 1913 as compared with 1912 was 1,577,922 short tons, or 9.8 per cent, in

quantity and $2,254,472, or 10.8 per cent, in value. The average value per ton advanced from $1.29 to $1.31. The increased production in 1913 was due to several causes. During a part of 1912 some of the larger companies were in the hands of receivers and this condition cut down the possible output for that year. The production was further restricted by the burning of the tipple at one of the large mines. The tipple was not rebuilt until the early part of 1913. Several new mines were opened in 1913 and these have been furnishing a gradually increasing output. Some of the older mines have added improvements and extended their workings to provide for an increased tonnage. Labor conditions were much better in 1913 than in either 1912 or 1911, for, although in some districts there was a scarcity rather than a surplus, other districts reported a better labor supply, miners having been recruited from other lines of employment. Car shortage was less acute than in recent years prior to 1913, as some of the large coal-carrying roads have added materially to their facilities for handling the output. The increased tonnage went principally to points outside the State, as the demand for manufacturing, transportation, and domestic consumption within the State was not above normal. The most notable feature in the trade was the increased bunker requirements on the Gulf coast and larger shipments of coke to western points. The relations between operators and mine workers were generally harmonious and increased wages were put in force in February. Earnings by miners and mine laborers in 1913 are said to have been higher than ever before in the history of coal mining in Alabama. Improved sanitary and living conditions put into effect by many companies added to the general betterment.

The average tonnage per man for 1913 showed an increase over 1912 from 712 to 720, but there was a slight falling off in the average output per man per day from 2,91 to 2.82. The former was due to the larger number of days worked—255 in 1913 against 245 in 1912, and the latter partly to the amount of development work in progress during 1913 and partly to the larger number of new recruits. The number of men employed in 1913 was 24,552, against 22,613 in 1912.

The production by the use of machines increased from 3,742,549 short tons in 1912 to 4,124,301 tons in 1913, the

per centage to the total output being about the same in both years, 23.2 per cent in 1912 and 23.3 per cent in 1913. The number of machines increased from 353 to 377. Of the latter 249 were punchers, 42 chain breast, 20 long wall, and 66 short wall. It is unfortunate to be obliged to record a marked increase in the quantity and percentage of coal shot off the solid. In 1912 the quantity of powder-mined coal reported was 5,658,-457, or 35.1 per cent of the total; in 1913 it was 7,052,234 tons, or 39.9 per cent. The hand-mined coal decreased from 6,658,-732 tons, or 41.4 per cent, in 1912, to 6,315,787 tons, or 35.7 per cent, in 1913.

The statistics of fatal accidents compiled by the Bureau of Mines shows that there were 124 men killed in the coal-mining operations of Alabama in 1913, all but 1 underground. More than half of the deaths, 68 in all, were due to falls of roof and coal, 27 to gas and dust explosions (including suffocations by mine gases), and 19 to mine cars and locomotives. In 1912 there were 121 fatal accidents in Alabama coal mines. The death rate per thousand in 1913 was 5 against 5.4 in 1912, and the number of tons mined for each life lost was 142,569 against 133,063.

The total time lost by strikes in 1913 was 27,041 days, 1,048 men being idle for an average of 26 days.

Nearly one-half of the coal mined in Alabama in 1913 was washed before being marketed or used in the manufacture of coke. The quantity washed was 8,149,082 tons, yielding 7,210,-588 tons of cleaned coal and 938,494 tons of refuse. The difference of 1.3 per cent between the production as reported to the Geological Survey and to the State mine inspector is probably due to the inclusion in the reports to the latter of some of the refuse and its omission in the reports to the Survey. The quantity of refuse actually reported to the Survey as removed at the mines and deducted from the gross tonnage was more than twice the difference between the Federal and State figures.

The statistics of production of coal in Alabama in 1912 and 1913, with the distribution of the product for consumption, are shown in the following table:

Coal production of Alabama in 1912 and 1913, by counties, in short tons.

1912.

County	Loaded at mines for shipment	Sold to local trade and used by employees	Used at mines for steam and heat	Made into coke	Total quantity	Total value	Average price per ton	Average number of days active	Average number of employees
Bibb	1,662,198	9,823	109,314	....	1,781,335	$2,621,682	$1.47	272	2,948
Blount	143,603	1,189	1,600	....	146,342	181,036	1.24	211	282
Etowah	166,866	3,067	1,875	....	171,808	249,749	1.46	265	760
Jefferson	6,168,715	81,368	339,211	1,585,555	8,174,849	10,433,723	1.28	251	10,922
St. Clair	722,276	2,456	25,021	....	749,753	959,219	1.28	291	725
Shelby	463,788	3,501	29,660	....	496,949	872,501	1.76	250	878
Tuscaloosa	631,114	12,038	48,863	188,952	880,967	1,091,882	1.24	239	1,220
Walker	3,271,284	32,080	102,681	141,967	3,547,962	4,158,094	1.17	211	5,079
Winston	18,550	105	75	....	18,730	27,793	1.48	220	57
Other counties* and small mines	124,627	2,059	5,719	....	132,405	233,568	1.76	229	242
Total	13,372,521	147,586	664,019	1,916,474	16,100,600	20,829,252	1.29	245	22,613

1913.

County	Loaded at mines for shipment	Sold to local trade and used by employees	Used at mines for steam and heat	Made into coke	Total quantity	Total value	Average price per ton	Average number of days active	Average number of employees
Bibb	1,802,243	9,214	99,569	....	1,911,026	$2,979,240	$1.56	274	3,158
Blount	174,580	2,758	1,620	....	178,958	236,448	1.32	203	354
Etowah	135,815	725	1,252	....	137,792	171,600	1.25	256	209
Jefferson	7,149,844	83,353	412,891	1,382,746	9,028,834	11,790,737	1.31	266	11,648
St. Clair	861,579	2,909	25,891	....	890,379	1,150,457	1.29	277	798
Shelby	457,313	4,469	35,787	....	497,569	862,783	1.73	257	850
Tuscaloosa	699,690	13,891	68,836	134,888	917,305	1,172,227	1.28	271	1,183
Walker	3,671,708	42,809	101,760	150,986	3,967,263	4,481,373	1.13	223	6,081
Winston	24,841	60	50	....	24,951	36,724	1.47	228	67
Other counties*	116,423	2,162	5,030	....	123,615	200,059	1.62	233	259
Small mines	....	830	....	....	830	2,076	2.50	......	......
Total	15,094,036	163,180	752,686	1,668,620	17,678,522	23,083,724	1.31	255	24,552

*Cullman, Jackson, and Marion.

In the following table is presented a statement of the production of coal in Alabama, by counties, during the last five years, with increase and decrease in 1913 as compared with 1912:

Coal production of Alabama, 1909-1913, by counties, in short tons.

County	1909	1910	1911	1912	1913	Increase (+ or decrease (—), 1913
Bibb	1,338,243	1,580,564	1,633,197	1,781,335	1,911,026	+ 129,691
Blount } Cullman	186,261	*235,456	*210,070	*276,429	*300,092	+ 23,663
Etowah	46,194	172,465	255,860	171,308	137,792	— 33,516
Jefferson	7,176,922	8,298,702	7,776,390	8,174,849	9,028,834	+ 853,985
St. Clair	354,005	428,409	529,211	749,753	890,379	+ 140,626
Shelby	524,925	488,141	463,089	496,949	497,569	+ 620
Tuscaloosa	1,006,989	1,081,219	1,031,658	880,967	917,305	+ 36,338
Walker	2,973,776	3,788,479	3,103,595	3,547,962	3,967,263	+ 419,301
Winston	32,278	16,442	16,424	18,730	24,951	+ 6,221
Other counties and small mines	63,857	21,585	1,927	2,318	3,311	+ 993
Total	13,703,450	16,111,462	15,021,421	16,100,600	17,678,522	+ 1,577,922
Total value	$16,306,286	$20,236,853	$19,079,949	$20,829,252	$23,083,724	+$2,254,472

*Includes production of Marion County.

The statistics of production in Alabama from 1840 to the close of 1913 are shown in the following table:

Production of coal in Alabama from 1840 to 1913, in short tons.

Year	Quantity	Year	Quantity	Year	Quantity	Year	Quantity
1840	946	1859	9,000	1878	224,000	1897	5,893,770
1841	1,000	1860	10,200	1879	280,000	1898	6,535,283
1842	1,000	1861	10,000	1880	323,972	1899	7,593,416
1843	1,200	1862	12,500	1881	420,000	1900	8,394,275
1844	1,200	1863	15,000	1882	896,000	1901	9,099,052
1845	1,500	1864	15,000	1883	1,568,000	1902	10,354,570
1846	1,500	1865	12,000	1884	2,240,000	1903	11,654,324
1847	2,000	1866	12,000	1885	2,492,000	1904	11,262,046
1848	2,000	1867	10,000	1886	1,800,000	1905	11,866,069
1849	2,500	1868	10,000	1887	1,950,000	1906	13,107,963
1850	2,500	1869	10,000	1888	2,900,000	1907	14,250,454
1851	3,000	1870	11,000	1889	3,572,983	1908	11,604,593
1852	3,000	1871	15,000	1890	4,090,409	1909	13,703,450
1853	4,000	1872	16,800	1891	4,759,781	1910	16,111,462
1854	4,500	1873	44,800	1892	5,529,312	1911	15,021,421
1855	6,000	1874	50,400	1893	5,136,935	1912	16,100,600
1856	6,800	1875	67,200	1894	4,397,178	1913	17,678,522
1857	8,000	1876	112,000	1895	5,693,775		
1858	8,500	1877	196,000	1896	5,748,697	Total	254,954,358

The following tables give other details concerning the coal production of Alabama, including areas of the coal fields of Alabama and of the United States, with estimates of original and present supply, etc.; rank of first five coal-producing States; production by classes of mines; labor statistics; strikes and suspensions; machines used and methods of mining, etc.:

Area of coal fields of Alabama and of the United States, estimates of original and present supply, and the production to the close of 1913.

	Area	Estimated original supply	Production in 1913	Total production to close of 1913	Total exhaustion to close of 1913	Estimated available supply
	Sq. Mi.	Short Tons	Sh. Tons	Short Tons	Short Tons	Short Tons
Alabama	8,455	67,583,000,000	17,678,522	254,954,358	382,400,000	67,200,600,000
U. S.	450,889	3,553,383,400,000	570,048,125	9,844,247,843	15,877,071.700	3,538,506,328,300

Rank of first ten coal-producing States in 1912 and 1913, with quantity and value of products and percentage of each.

1912.

Production				Value			
Rank	State or Territory	Quantity (short tons)	Percentage of total product'n	Rank	State or Territory	Value	Percentage of total value
1	Pennsylvania:			1	Pennsylvania:		
	Anthracite	84,361,598	15.8		Anthracite	$177,622,626	25.6
	Bituminous	161,865,488	30.3		Bituminous	169,370,497	24.4
2	West Virginia	66,786,687	12.5	2	Illinois	70,294,338	10.1
3	Illinois	59,885,226	11.2	3	West Virginia	62,792,234	9.0
4	Ohio	34,528,727	6.4	4	Ohio	37,083,363	5.3
5	Kentucky	16,490,521	3.1	5	Alabama	20,829,252	3.0
6	Alabama	16,100,600	3.0	6	Indiana	17,480,546	2.5
7	Indiana	15,285,718	2.8	7	Kentucky	16,854,207	2.4
8	Colorado	10,977,824	2.0	8	Colorado	16,345,336	2.4
9	Virginia	7,846,638	1.5	9	Iowa	13,152,088	1.9
10	Wyoming	7,368,124	1.4	10	Wyoming	11,648,088	1.7

1913.

Production				Value			
Rank	State or Territory	Quantity (short tons)	Percentage of total product'n	Rank	State or Territory	Value	Percentage of total value
1	Pennsylvania:			1	Pennsylvania:		
	Anthracite	91,524,922	16.1		Anthracite	$195,181,127	25.7
	Bituminous	173,781,217	30.5		Bituminous	193,039,806	25.4
2	West Virginia	71,308,982	12.5	2	West Virginia	71,872,165	9.5
3	Illinois	61,618,744	10.8	3	Illinois	70,313,605	9.2
4	Ohio	36,200,527	6.3	4	Ohio	39,948,058	5.3
5	Kentucky	19,616,600	3.4	5	Alabama	23,083,724	3.0
6	Alabama	17,678,522	3.1	6	Kentucky	20,516,749	2.7
7	Indiana	17,165,671	3.0	7	Indiana	19,001,881	2.5
8	Colorado	9,232,510	1.6	8	Colorado	14,035,090	1.8
9	Virginia	8,828,068	1.5	9	Iowa	13,496,710	1.8
10	Iowa	7,525,936	1.3	10	Kansas	12,036,292	1.6

Production of coal in Alabama in 1912 and 1913, according to classes of mines, in short tons.

1912.

	Mines		Production		
	Number	Percentage	Total	Average	per Mine
First Class: (Mines producing over 200,000 tons)	13	6.0	3,734,754	287,289	23.2
Second Class: (Mines producing from 100,000 to 200,000 tons)	50	23.0	7,364,764	147,295	45.7
Third Class: (Mines producing from 50,000 to 100,000 tons)	41	18.9	2,967,102	72,368	18.4
Fourth Class: (Mines prdoucing from 10,000 to 50,000 tons)	75	34.6	1,843,623	24,582	11.5
Fifth Class: (Mines producing less than 10,000 tons)	38	17.5	190,357	5,009	1.2
Total	217	....	16,100,600	74,196	....

1913.

	Number	Percentage	Total	Average	per Mine
First Class: (Mines producing over 200,000 tons)	19	8.5	6,112,051	321,687	34.6
Second Class: (Mines producing from 100,000 to 200,000 tons)	42	18.7	5,862,478	139,583	33.2
Third Class: (Mines producing from 50,000 to 100,000 tons)	44	19.6	3,121,545	70,944	17.6
Fourth Class: (Mines producing from 10,000 to 50,000 tons)	94	42.0	2,448,122	26,044	13.8
Fifth Class: (Mines producing less than 10,000 tons)	25	11.2	133,496	5,340	0.8
Total	224	....	17,677,692	78,918	....

LABOR STATISTICS.

Statistics of labor employed in coal mines of Alabama 1908-1913.

Year	Number of days active	Average Number Employed
1908	222	19,197
1910	249	22,210
1911	227	22,707
1912	245	22,618
1913	255	24,552

Average production per man compared with hours worked per day, and average number of days worked 1910-1912.

Year	8 hours		9 hours		10 hours		All others	Total		Average Tonnage	
	Mines	Men	Mines	Men	Mines	Men	Men	Men	Days Worked	Per Year	Per Day
1910	18	766	86	2,633	134	17,306	1,525	22,230	249	725	2.91
1911	15	550	50	5,345	102	12,628	4,184	22,707	227	662	2.92
1912	11	338	46	4,145	107	13,938	4,192	22,618	245	712	2.91
1913	13	420	36	2,496	135	18,185	3,451	24,552	255	720	2.82

Statistics of labor strikes in the coal mines of Alabama in 1912 and 1913.

1912			1913		
Number of men on strike	Total days lost	Average number of days lost per man	Number of men on strike	Total days lost	Average number of days lost per man
384	12,323	32	1,048	27,041	26

MACHINES USED AND METHODS OF MINING.

Number and kind of machines in use in Alabama in 1912 and 1913.

Year	Pick	Chain Breast	Long Wall	Short Wall	Total
1912	222	60	12	59	353
1913	249	42	20	66	377

Bituminous coal mined by machines in Alabama in 1912 and 1913.

Year	Number of machines in use	Number of tons mined by machines	Total tonnage of Alabama	Percentage of total product mined by machines
1912	353	3,742,549	16,100,600	23.2
1913	377	4,124,301	17,678,522	23.3

Quantity and percentage of coal mined by different methods in Alabama in 1912 and 1913, short tons.

Year	Mined by hand	Percentage	Shot off the solid	Percentage	Mined by machines	Percentage	Not reported	Percentage	Total production
1912	6,658,732	41.4	5,658,457	35.1	3,742,549	23.2	40,862	0.3	16,100,600
1913	6,315,787	35.7	7,052,234	39.9	4,124,301	23.3	186,200	1.1	17,678,522

Coal Washing Operations.

Coal washed at the mines in Alabama in 1912 and 1913, with quantity of washed coal and of refuse obtained from it, short tons.

Year	Quantity of coal washed	Quantity of cleaned coal	Quantity of refuse
1912	7,187,211	6,325,946	861,265
1913	8,149,082	7,210,588	938,494

Average Value of Alabama Coal.

Average value per short ton for coal at the mines in Alabama since 1908.

1908	1909	1910	1911	1912	1913	Advance in 1913
$1.26	$1.19	$1.26	$1.27	$1.29	$1.31	$0.02

COKE.

E. W. PARKER.

THE production of coke in Alabama increased from 2,975,489 short tons, valued at $8,098,412, in 1912, to 3,323,664 tons, valued at $9,627,170, in 1913. The gain was 348,175 tons, or 11.7 per cent, in quantity, and $1,528;758, or 18.9 per cent, in value. All of the increased production, and more, was in the output of retort oven or by-product coke. There are in Alabama four retort oven establishments with a total of 700 ovens, and in 1913 these establishments produced 2,022,959 tons of coke, or a little more than 60 per cent of the total output, whereas 22 active beehive plants with an aggregate of 4,135 ovens in blast produced 1,300,705 tons, or a little less than 40 per cent of the total. The average production per oven in the by-product plants was 2,890 tons, and the average production for each beehive oven was 315 tons.

The increase in the production of by-product coke in 1913 over 1912 was 673,162 tons, or nearly double the total increase. The output of beehive coke decreased 324,987 tons. The value of the by-product coke showed an increase of $1,751,538, or $222,780 more than the total increase, the difference representing the decrease in the value of beehive coke. Moreover, the average yield of coal in coke from the retort ovens was 71.4 per cent, whereas the average yield in the beehive ovens was 54.5 per cent. There is not the marked difference in the values of retort and beehive cokes (and in favor of the former) in Alabama as is shown in some States, for in Alabama the retort ovens, like the beehive, are located near the mines, and the two in that respect are somewhat on a parity, whereas in most of the States where retort coke is made the ovens are at considerable distances from the mines, and the transportation charges assessed against the coal are added to the value of the coke. In fact the Alabama, beehive coke had a higher value per ton in 1913 than the retort coke, the averages per ton being $3.38 for beehive coke and $2.58 for retort coke. The explanation of this seeming inconsistency lies in the fact that all of the retort

coke is used by the producers in their own furnaces, and the coke is charged to the furnaces at little more than cost, whereas the greater part of the beehive product is commercial coke, some of it for foundry use, and profits are included in the value.

That the beehive oven has had its day in Alabama and is on the decline is evinced by the facts that no new ovens of that type have been built in the last four years and that 20 establishments, with a total of 3,447 ovens, out of a total of 42 establishments, with 9,548 ovens, were idle in 1913, not counting the ovens out of blast at plants that produced some coke in 1913. There were fewer beehive ovens in existence in Alabama in 1913 than in 1908, five years before. The number of retort ovens increased from 620 in 1912 to 700 in 1913, 80 of the 100 ovens of that type reported as in course of construction at the close of 1912 having been completed and put in blast. The 700 completed ovens include 280 Semet-Solvay ovens (240 at Ensley and 40 at Tuscaloosa and 420 Koppers ovens (280 at Fairfield, formerly known as Corey, and 140 at Woodward). The only new ovens in course of construction at the close of 1913 were 20 Semet-Solvay ovens which were being added to the Tuscaloosa plant.

Rank of Coke-Producing States.

The record of coke production in 1913 effected few changes in the relative importance of the State in connection with that industry. Virginia superseded Colorado as sixth in rank, but with that exception the first 12 States held the same position in 1913 as in 1912. Pennsylvania, of course, stands preeminently first, with Alabama second, Indiana third, and West Virginia fourth, but if all the coke made from West Virginia coal were produced in that State it would be well fixed in second place, as by far the larger part of the coke manufactured in Ohio, Indiana, and Illinois is from West Virginia coal. As, however, the production of coke in retort ovens at or near the points of consumption is likely to continue to increase in greater proportion and the beehive ovens to disappear gradually from the mining regions, it is not probable that West Virginia will again assume its former importance as a coke-producing State.

The quantity of coke made in West Virginia in 1913 was less than one-half of that made from West Virginia coal in ovens outside the State.

The positions held by the coke-producing States are shown in the following table:

Rank of the States in production of coke, 1909-1913.

State	1909	1910	1911	1912	1913	State	1909	1910	1911	1912	1913
Pennsylvania	1	1	1	1	1	Tennessee	13	13	14	14	13
Alabama	3	3	2	2	2	Ohio	15	14	15	13	14
Indiana	22	17	6	3	3	Utah	16	16	17	15	15
West Virginia	2	2	3	4	4	Kentucky	19	20	19	18	16
Illinois	5	4	4	5	5	New Jersey	14	15	16	17	17
Virginia	4	5	7	7	6	Maryland	12	12	13	16	18
Colorado	6	6	5	6	7	Minnesota	17	18	18	19	19
New York	7	7	8	8	8	Washington	20	19	20	20	20
Wisconsin	8	8	9	9	9	Georgia	18	21	21	21	21
Massachusetts	9	9	10	10	10	Kansas	......	24	22	22	......
Michigan	11	11	12	11	11	Montana	21	22	......	......	......
New Mexico	10	10	11	12	12	Oklahoma	......	23	......	......	......

The production of coke in Alabama in 1880, 1890, 1900, and annually from 1909 to 1913, is shown in the following table:

Statistics of the manufacture of coke in Alabama, 1880-1913.

Year	Establishments	Ovens		Coal used (short tons)	Yield of coal in coke (per cent)	Coke produced (short tons)	Total value of coke at ovens	Value of coke at ovens per ton
		Built	Building					
1880	4	316	100	106,283	57.0	60,781	$183,063	$3.01
1890	20	4,805	371	1,809,964	59.0	1,072,942	2,589,447	2.41
1900	30	6,529	690	3,582,547	58.9	2,110,837	5,629,428	2.67
1909	43	10,061	0	5,080,764	60.7	3,085,824	8,068,267	2.61
1910	43	10,132	340	5,272,322	61.6	3,249,027	9,165,821	2.82
1911	44	10,121	280	4,411,298	62.6	2,761,521	7,593,594	2.75
1912	46	10,208	100	4,585,498	64.9	2,975,489	8,098,412	2.72
1913	46	*10,284	†20	5,218,323	63.6	3,323,664	9,267,170	2.90

*Includes 280 Semet-Solvay and 420 Koppers ovens. †Semet-Solvay ovens.

Comparison of the production and value of coke in Alabama in 1912 and 1913.

	Number of ovens	Coal charged (short tons)	Coke produced (short tons)	Total value of coke at ovens	Percentage of total U. S. value
1912	10,208	4,585,498	2,975,489	$8,098,412	7.24
1913	10,284	5,218,323	3,323,664	9,627,170	7.46
Increase	76	632,825	348,175	1,528,758	....
Percentage	0.74	13.8	11.7	18.9	....

More than 80 per cent of the coal used in the manufacture of coke in Alabama is washed before being charged into the ovens. In 1913, out of a total of 5,218,323 tons of coal made into coke, 4,349,664 tons were washed. Of the washed coal used, 3,665,441 tons were slack and 684,223 tons were mine run. The unwashed mine-run coal used was 868,659 tons. No unwashed slack was used in 1913.

The character of the coal used in the manufacture of coke in Alabama in 1890, 1900, and for the last five years, is shown in the following table:

Character of coal used in the manufacture of coke in Alabama, 1890-1913, in short tons.

Year	Run of mine		Slack		Total
	Unwashed	Washed	Unwashed	Washed	
1890	1,480,669	0	206,106	123,189	1,809,964
1900	1,729,882	152,077	165,418	1,535,170	3,582,547
1909	713,992	2,153,801	0	2,212,971	5,080,764
1910	771,931	1,308,085	0	3,192,306	5,272,322
1911	693,135	1,295,109	2,937	2,420,117	4,411,298
1912	747,305	896,421	18,793	2,922,979	4,585,498
1913	868,659	684,223	0	3,665,441	5,218,323

Quantity and value of coal used in the manufacture of coke in Alabama in 1912 and 1913, and quantity and value of same per ton of coke.

Year	Coal used (short tons)	Total value of coal	Value of coal per ton	Quantity of coal per ton of coke (short tons)	Value of coal to a ton of coke
1912	4,585,498	$6,177,876	$1.35	1,541	$2,080
1913	5,218,323	7,609,963	1.46	1,570	2,292

Character of coal used in the manufacture of coke in Alabama in 1912 and 1913, in short tons.

Year	Run of mine		Slack		Total			
	Unwashed	Washed	Unwashed	Washed	Unwashed	Percentage	Washed	Percentage
1912	747,305	896,421	18,793	2,922,979	766,098	16.7	3,819,400	83.3
1913	868,659	684,223	0	3,665,441	868,659	16.6	4,349,664	83.4

Statistics of the production of coke in beehive and retort ovens in Alabama, 1912 and 1913.

Year	Beehive coke		By-product coke		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1912	1,625,692	$4,623,996	1,349,797	$3,474,416	2,975,489	$8,098,412
1913	1,300,705	4,401,216	2,022,959	5,225,954	3,323,664	9,627,170

Record of by-product ovens in Alabama 1909-1913.

Year	Built	Building
December 31, 1909	280	0
December 31, 1910	280	340
December 31, 1911	340	280
December 31, 1912	620	100
December 31, 1913	700	20

Complete list of retort coke-oven plants of Alabama, Jan. 1, 1914.

Town	System	Name of company owning plant	Number of installments	Date put in operation	Number of ovens	Uses of coke	Uses of surplus gas
Ensley (near Birmingham)	Semet-Solvay	Tennessee Coal, Iron & R. R. Co.	First	Oct., 1898	120	Blast furnace	Fuel
			Second	Mar., 1902	120	Blast furnace	Fuel
Tuscaloosa	Semet-Solvay	Central Iron & Coal Co.	First	Feb., 1906	40	Blast furnace	Fuel
Woodward	Koppers	Woodward Iron Co.	First	1911	60	Blast furnace	Fuel and power
Woodward	Koppers	Woodward Iron Co.	Second	1913	80	Blast furnace	Fuel and power
Fairfield	Koppers	Tennessee Coal, Iron & R. R. Co.	First	1912	280	Blast furnace	Fuel and power

GOLD AND SILVER.

H. D. McCaskey.

THE mine production of gold in Alabama in 1913 was 536.67 fine ounces, valued at $11,094, and of silver 117 fine ounces, valued at $71; against 809.0 fine ounces of gold valued at $16,724, and 168 fine ounces of silver valued at $103, in 1912. The gold output was all from gold quartz mines and the silver production was entirely from refining the gold bullion produced. No copper, lead or zinc output was reported from Alabama in either 1912 or 1913.

The following table shows the mine production of gold and silver in Alabama since 1905, when the United States Geological Survey first collected detailed figures from the mines of the Eastern States. The decrease of production shows results from comparison with the corresponding Survey mine figures for 1912.

Production of gold and silver in Alabama from 1905 to 1913, inclusive.

	Ore Sold or Treated (short tons)	Gold		Silver		Total value
		Quantity oz.	Value	Quantity oz.	Value	
1905	16,425	2,009.0	$41,530	336	$203	$41,733
1906	8,565	1,137.0	24,921	124	83	25,004
1907	18,400	1,256.9	25,982	439	290	26,272
1908	11,174	1,993.4	41,208	282	149	41,357
1909	9,886	1,414.4	29,239	212	110	29,349
1910	9,763	1,662.2	33,533	268	145	33,678
1911	6,360	915.0	18,916	171	91	19,007
1912	5,693	809.02	16,724	168	103	16,827
1913	....	536.67	11,094	117	71	11,165
Decrease in 1913	....	272.35	5.630	51	32	5.662
Percentage	....	33.66	33.66	30.36	31.07	33.65

GRAPHITE.

BY EDSON S. BASTIN.

GRAPHITE is widely distributed among the metamorphic rocks of Alabama,[1] in which it occurs in two forms: (1) In the feebly crystalline schists which have been called the Talladega slates,[2] and which in part at least are Paleozoic sediments of as late age as the "Coal Measures," graphite is often found as a black graphitic clay free from grit. In this condition the graphite is difficult to separate from the other matter with which it is mixed, and the material has not yet been utilized commercially to any great extent. Examples of this mode of occurrence may be seen near Millerville, in Clay County, and about Blue Hill, in Tallapoosa County. (2) In the mica schists and other highly crystalline rocks graphite is found in the form of thin crystalline flakes, which may be separated from the associated minerals. Graphitic schists of this type are now being worked at three localities and have in the past been worked at several others.

Three graphite companies were active in Alabama during 1913. One of these, the Alabama Graphite Co., with mine and mill 6 miles west of Ashland, Clay County, reported a notable increase in production as compared with 1912. The other, the Quenelda Graphite Co. (formerly the Allen Graphite Co.), at Quenelda, Clay County, has completed a new mill to replace the one destroyed by fire in 1911. This mill was put in operation November 1, 1913, and an important quantity of flake graphite was marketed during the year. The mine and mill 4½ miles west of Ashland, formerly operated by the Ashland Graphite Co., have not been in operation since 1911, and it is reported that the company has dissolved. The Flaketown Graphite Co., near Mountain Creek, in Chilton County, reported an important production.

The properties of the Quenelda Graphite Co. and that formerly operated by the Ashland Graphite Co. and a few other

1 Smith, E. A., Min. Industry, vol. 16, p. 568, 1907.
2 McCalley, H., Alabama Geol. Survey Rept. valley regions, pt. 2, pp. 36-38, 1897.

Alabama graphite properties were visited by the writer in 1911. The original reports upon them being exhausted, his observations are reprinted below. The property of the Alabama Graphite Co. was not developed at that time and has not since been visited.

CLAY COUNTY.

Ashland, the shipping point of the Clay County graphite properties, is the terminus of a short branch of the Atlanta, Birmingham & Atlantic Railroad. This branch is 7 miles long and joins the main line at Pyriton. The freight rate on refined graphite from Ashland to New York City is about $7 a long ton.

QUENELDA GRAPHITE CO. (FORMERLY THE ALLEN GRAPHITE CO.)

The quarry and mill of this company are located a little over 8 miles west of Ashland, at a settlement shown on the United States Geological Survey's map of the Ashland quadrangle under the name "Graphite." The mine is about half a mile from the mill, with which it is connected by a tramway. The concentrate is hauled over a fairly good road to Ashland for shipment. The mining is entirely from open pits, and because of the decomposed character of the rock can be accomplished largely with the aid of pick, shovel, and crow-bar, without much drilling and blasting.

The main pit is about 450 feet in length, 100 feet in average width, and about 60 feet in maximum depth. A small pit just east of the main pit and on the same graphitic band is about 100 feet long, 90 feet wide, and 25 feet deep. A third pit has been opened on the same band of graphitic schist about 1,000 feet east of the main pit on the west face of another hill. This is about 90 feet wide, about 200 feet long, and about 40 feet deep. The strike of the schist at the north end of the main pit is N. 80° E., with a dip of 75° S. This is fairly typical for the deposit as a whole.

The rock mined is highly schistose and is composed largely of quartz and graphite. A white, fibrous mineral, probably sillimanite, is also abundant. Feldspar and mica are rare. Few of the thin graphite flakes so far seen by the writer exceed 2 millimeters across and most of them are under 1½ millimeters. They are arranged subparallel to one another, and to this arrangement and a similar orientation of the sillimanite (?) prisms is largely due the schistosity of the rock. At the west end of the main pit a dike of coarse granite, 1 to 1½ feet wide, parallels the foliation of the schist, and in the easternmost pit the graphitic schist has also been intruded by an irregular body of coarse granite pegmatite carrying muscovite crystals up to 3 inches across. The graphitic beds here are also disturbed by faulting. The contact metamorphic effects of these small intrusions on the graphitic schist appear to be slight.

The mill which was in operation at the time of the writer's visit has since been destroyed by fire and replaced by a new one, but as the old mill was studied in some detail a description of the process may still be of value.

The milling process in the old mill was divided into three principal stages—(1) crushing and drying; (2) preliminary wet concentration; and (3) final dry concentration.

The most important step in the milling process was the preliminary concentration by water flotation. In these concentrators the dry crushed rock was spread in a thin stream upon the surface of slowly flowing water. The graphite being flaky was supported by the surface tension of the water and floated off, while the granular gangue, mainly quartz, sank and was sent to the dump. The process is cheap where water is plentiful. The tailings seen on the dump carried surprisingly little graphite; that which was present was usually attached to other minerals. Much fine grit, of course, floated off with the graphite but was removed in the final dry concentration.

The crude rock was said by the operators to average about 5 per cent graphite. For two successive years (September, 1908, to September, 1910) the finished product formed, respectively, 2.95 and 2.7 per cent by weight of the crude rock treated. Four principal grades were produced, whose relative proportions were about as follows:

Grades of flake graphite produced by Allen Graphite Co., Clay County, Alabama.

		Per cent.
Grade C.	Crucible flake	36
Grade 1.	Lubricating flake (coarse)	11
Grade 2.	Lubricating flake (fine)	18
Grade D.	Dust for foundry facings, etc.	35
		100

The highest grade averaged over 90 per cent graphite; the dust average about 50 per cent graphite. The average prices f. o. b. New York in 1911 were: Grade C, 6½ cents per pound; grade 1, 5½ cents per pound; grade 2, 4½ cents per pound; and grade D, 1 cent per pound.

Ashland Graphite Co.

The quarry and mill of the Ashland Graphite Co., which has not been a producer since 1911, are located about 4½ miles west of Ashland. The company was the successor to the Enitachopco Graphite Co. The product of the plant was hauled by team to Ashland. The workings at this property consist of two open pits located in the same belt of graphite schist. The two pits are on neighboring knolls, and the mill is in the small valley between them. The largest or eastern pit is about 400 feet long, 30 to 50 feet wide, and 50 feet deep. It follows along the strike of a band of graphitic schist which averages about 30 feet in width, though broadening locally to about 50 feet. The strike is about N. 55° E. and the average dip is about 45° E. The second pit, located west of the mill, is about 150 feet long, 20 feet wide, and about 20 feet deep. The trend of the schists is similar to that at the larger pit.

The graphitic rock at this quarry is similar in general to that at Quenelda quarry. The schist is too much decomposed for the complete identification of all the minerals, but quartz is the principal component. As a rule mica is rare, but the brown mica biotite is common in a few places. The graphite forms thin flakes, mostly under 1 millimeter in diameter, although some reach 2 millimeters. No igneous rocks were seen in association with the graphitic schist at this property. The rock being more or less decomposed, can be excavated with pick

and crowbar with occasional blasting. It is loaded into tram-cars and hauled to the mill.

Coosa County.

A graphite prospect is located about 2 miles northwest of Goodwater, a station on the Central of Georgia Railway. At this locality a large number of small prospect pits are scattered over an area of several acres, and nearly all show graphitic quartz schist. The prospects are on a steep southwest hillside overlooking the iron bridge where the wagon road from Goodwater to Pine Grove crosses Hatchet Creek. The rock is gray when fresh and highly schistose and strikes nearly east and west, with a dip of about 45° S. It is almost identical in character with the graphitic schist worked in Clay County and consists largely of quartz and graphite, the latter in flakes mostly under 1 millimeter in diameter. Very little mica is present. An analysis of a composite sample of graphitic schist collected from a large number of pits on this property showed 2 per cent of graphite, but in certain portions the percentage will undoubtedly be greater. The deposit is unquestionably a large one and its situation on a steep hillside would afford opportunity to work to a considerable depth by open-pit methods. The neighboring Hatchet Creek could furnish abundant water for wet concentration of the graphite.

A second deposit, probably of similar character, has been prospected between Mount Olive and Hollins. It was not visited by the writer, but is said to be of considerable size.

Production and vaule of crystalline graphite in 1912 and 1913.

	Quantity Pounds	Value	Percentage of total U. S. quantity	Percentage of total U. S. value
1912	534,100	$21,364	6.95	9.68
1913	2,020,910	87,336	29.73	29.73
Increase	1,486,810	65,972		
Percentage	278.38	308.80		

IRON ORE.

EUGENE A. SMITH.

IRON ores of Alabama in the order of their economic importance are (1) red ore or hematite; (2) the brown ore or limonite; (3) the gray ore. The black band and clay iron stone have been noticed as occurring in a number of places, but only the red ore and the brown ore have been mined on any large scale.

Practically all the ore mined in Alabama is smelted in the State, the shipments out of the State being about equal to those received from other states.

The tables given below will show the rank of Alabama among the States of the Union both in the production of iron ore and in pig iron.

RED ORE OR HEMATITE.

Practically all the ore of this quality mined in Alabama occurs in the Clinton or Red Mountain formation. The Red Mountain ridges occur on each side of the anticlinal valleys which separate the coal fields. In places the red ore ridges are lacking on one side, usually the western, of the valleys being cut out by faults, while on the other hand the ridge may be duplicated on one side of the valley by the same faults.

In most of the valley occurrences the moderate dips of the ore bed are on the eastern side and there are also practically all of the ore mines. Murphrees Valley makes an exception to this, the moderate dips and the iron mines being on the western side. The iron ore occurs mainly in the central part of the formation in seams or beds one to five in number, which vary in thickness from a few inches to thirty feet.

While the ore seams are very persistent along the outcrop which in Alabama must be as much as 50 miles, yet they vary greatly from place to place, being either too thin or too lean for profitable working in the greater part of this distance.

The most important development of the Clinton ore in this State and in the world is along the 15 or 16 miles stretch of the east Red Mountain between Birmingham and Bessemer, and there is a practically continuous series of mines and strippings for this entire distance. Much mining of this ore has also been done near Gate City, Village Springs, Attalla, Gadsden, Round Mountain, Gaylesville, Ft. Payne, Valley Head, etc.

The completion in October, 1912, of a diamond drill boring in Shades Valley, within a mile of the base of Shades Mountain, gives a definite answer to the speculations concerning the occurrence of red ore under Shades Valley. This boring shows that there is no falling off in the thickness and quality of the ore with distance from the outcrop, and that the depth of the ore below the surface at a distance of more than 2½ miles from the outcrop on Red Mountain is not too great for shaft mining.

The elevation of the surface at the drilling is 595 feet. The top of the ore was reached at a depth of 1,902 feet and a section of the seam in descending order is:

Ore (Self-fluxing)	9 ft. 6 in.
Shale	4 in.
Ore (Siliceous)	9 ft. 6 in.

An analysis of an average sample of the drill of the core of the upper bench, made by David Hancock, shows as follows:

	Per Cent.
Metallic iron	39.51
Silica	9.94
Alumina	3.34
Calcium Carbonate	24.20
Magnesium carbonate	.78
Metallic manganese	.20
Phosphorus	.32

The importance of this demonstration of a vast increase in the amount of red ore available immediately or in the near future, cannot well be overestimated.

In 1913 the Gulf States Steel Company acquired about 1,500 acres of land upon which the drill hole above mentioned was located. They commenced sinking double track slope to the ore, and the work is now about half completed (December, 1914). No serious difficulties have been encountered so far and it is probable that in about a year they will have reached the ore. In time this is likely to be the largest producing mine in the district.

Another drill hole was put down in Shades Valley in 1913 in the S. E. ¼ of the S. E. ¼ of section 19, township 19, range 3 W., but the records are not available for publication at the present time.

The hematite production of Alabama for 1913 was 4,370,823 long tons as against 3,814,361 tons for 1912, an increase for 1913 of 556,462 tons or 14.58 per cent. This 1913 production of hematite is 83.58 per cent of the total iron ore production of the State, and 7.05 per cent of the total iron ore production of the United States.

The average price per long ton of hematite in Alabama in 1912 was $1.16; in 1913, $1.18.

Brown Ore or Limonite.

This ore, the second in importance in the State and in the United States, furnished only 2.54 per cent of the total iron ore produced in the United States in 1913. The entire limonite production of the United States in 1913 was 1,577,019 long tons, of which Alabama contributed 844,917 tons, or 53.58 per cent. and the State holds, accordingly, the first rank in this industry.

In the early days of iron making and up to the year 1876 this was the only ore used in the catalan forges, bloomaries, and charcoal furnaces of the State. It was then demonstrated that good iron could be made at low cost from the red ores, with coke for the fuel.

In general the limonites are considered the best of the ores of Alabama and they command the highest prices and command a ready sale.

The usual mode of occurrence is in irregular masses of concretionary origin in the residual clays resulting from the de-

composition of limestones, and as a consequence the mining is uncertain and expensive. Limonite also occurs in regularly stratified seams or beds, and then it is the result of the alteration of pyrites or of carbonate ores. Practically all of the brown ore actually mined is that occurring in the residual clays above mentioned. Most of the ore before going to the furnace is washed and screened, and this manipulation, together with the cost of mining, makes it the most expensive of the iron ores, and it is therefore seldom used alone, but is usually mixed with the red ore in porportions determined by the quality of the iron desired. It is used alone in the chàrcoal furnaces and also in the coke furnaces when a particularly tough pig iron is wanted.

The limonite deposits are very numerous and are distributed over a broad expanse of country and in many places are known to be very extensive. In some of the deposits the ore is in nearly solid mass, in others it is much scattered, and in consequence the amount of foreign material necessary to be moved for every ton of ore produced, varies very much, not only in the different ore banks but also in the different parts of the same bank.

The deposits occur in nearly all the geological formations of the State, but in most of these the ore is either insufficient in quantity or not pure enough to be of much commercial value. The most important of the deposits, in point of extent and value, occur overlying the following formations, viz., the Knox Dolomite and the Weisner Quartzite, the Lauderdale Chert of the Lower Carboniferous, and the Lafayette. Some extensive beds of ore of inferior quality generally occur also in the Tuscaloosa formation of the Cretaceous, and in the upper part of the Lower Carboniferous and in the Metamorphic rocks.

The limonite or brown ore production of Alabama for 1913 was 844,917 long tons as against 749,242 tons in 1912, an increase of 95.675 tons or 12.77 per cent. The average price per long ton of iron ore marketed in Alabama in 1913 was $1.43; in 1913, $1.61.

The following tables show details concerning the production of iron ore in the State, together with the rank of the State in mined and in marketed iron ore, 1912 and 1913.

Iron ore mined in Alabama in 1912 and 1913, by varieties, with percentage of increase in 1913, in long tons.

Year	Hematite	Brown Ore	Total Quantity	Percentage of total U. S. produc'n.
1912	3,814,361	749,242	4,563,603	8.27
1913	4,370,823	844,917	5,215,740	8.42
Increase	556,462	95,675	652,137	
Percentage of increase 1913	14.58	12.77	14.29	

Iron ore marketed in Alabama in 1912 and 1913, by varieties, in long tons.

Year	Hematite	Brown Ore	Total Quantity	Total Value
1912	4,012,901	763,644	4,776,545	5,734,371
1913	4,488,176	845,042	5,333,218	6,648,569
Increase	475,275	81,398	556,673	914,198
Percentage of increase	11.84	10.67	11.66	15.94

Rank of first five states in mined and marketed production of iron ore in 1912 and 1913.

1912.

Rank	State	Mined: Quantity (long tons)	Mined: Percentage of total production	Marketed: Quantity (long tons)	Marketed: Percentage of total production	Marketed: Value	Marketed: Percentage of total value
1	Minnesota	36,481,768	62.43	34,249,813	60.07	$61,805,017	57.74
2	Michigan	11,191,430	20.29	12,797,468	22.44	29,003,163	27.09
3	Alabama	4,563,603	8.28	4,776,545	8.33	5,734,371	5.36
4	New York	1,216,672	2.21	1,167,405	2.05	2,938,026	2.74
5	Wisconsin	860,600	1.56	1,152,250	2.02	2,731,574	2.55

1913.

Rank	State	Mined: Quantity (long tons)	Mined: Percentage of total production	Marketed: Quantity (long tons)	Marketed: Percentage of total production	Marketed: Value	Marketed: Percentage of total value
1	Minnesota	38,658,798	62.37	36,603,331	61.37	80,789,025	61.72
2	Michigan	12,841,093	20.72	12,668,560	21.24	33,479,954	25.58
3	Alabama	5,215,740	8.42	5,333,218	8.94	6,648,569	5.08
4	New York	1,459,628	2.36	1,420,889	2.38	3,100,285	2.37
5	Wisconsin	1,018,272	1.64	896,243	1.50	2,149,397	1.64

Iron ore mines of Alabama that produced more than 50,000 long tons each in 1913.

Name of Mine	Nearest Town	Variety of Ore	Quantity
1. Red Mountain Group	Bessemer	Hematite	2,205,196
2. Woodward, 1, 2 and 3	Lipscomb	Hematite	586,010
3. Songo	Songo	Hematite	184,118
4. Raimund, No. 1	Bessemer	Hematite	183,638
5. Steinman	Steinman	Hematite	147,313
6. Greeley	Greeley	Brown Ore	127,006
7. Raimund, No. 2	Bessemer	Hematite	117,556
8. Crudup	Gadsden	Hematite	91,001
9. Ironaton	Ironaton	Brown	87,637
10. Raimund, No. 3	Bessemer	Hematite	67,903
11. Houston	Rickey	Brown	67,815
12. Docray	Docray	Brown	67,771
13. Tannehill	Goethite	Brown	62,503
14. Friedman	Woodstock	Brown	56,244
15. Spaulding	Birmingham	Hematite	56,192
16. Attalla	Attalla	Hematite	55,593

Total (16 mines)	4,163,496
Unspecified* (4 mines)	829,197
Tonnage from 20 mines producing more than 50,000 long tons each	4,992,693
Tonnage from 20 mines producing less than 50,000 long tons each	223,047
Grand total of Alabama production	5,215,740

*Includes the product of 4 mines, producing over 50,000 tons each, operated by 2 companies which do not permit the publication of individual statistics.

PIG IRON.

Quantity and value of pig iron, (exclusive of ferro-alloys) marketed in the United States in 1912 and 1913, (first five States), with increase or decrease and percentage of increase or decrease in 1913, in long tons.

State	1912		1913		Increase (+) or decrease (−) in 1913		Percentage of increase (+) or decrease (−) in 1913	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Pennsylvania	12,437,685	$181,569,299	12,871,349	$197,726,314	+433,664	+16,157,015	+ 3.49	+ 8.90
Ohio	7,127,176	93,140,369	6,918,961	103,824,517	−213,215	+10,684,148	− 2.90	+ 11.47
Illinois	2,806,378	42,828,816	2,892,263	45,796,966	+ 85,885	+ 2,968,150	+ 3.06	+ 6.93
New York	1,973,090	28,059,058	1,967,449	30,203,673	− 5,641	+ 2,144,615	− .29	+ 7.64
Alabama	1,987,753	21,371,053	1,924,762	23,242,374	− 62,991	+ 1,871,321	− 3.17	+ 8.76

Production of pig iron, (including ferro-alloys) in 1912 and 1913, (first five States), in long tons.
Bureau of Statistics of American Iron & Steel Institute.

State	1912			1913	
	Rank	Quantity	Percentage	Quantity	Percentage
Pennsylvania	1	12,552,181	42.28	12.954,936	41.84
Ohio	2	6,802,493	22.88	7,129,525	23.02
Illinois	3	2,887,859	9.71	2,927,882	9.45
New York	4	1,939,281	6.52	2,065,825	6.67
Alabama	5	1,862,681	6.27	2,057,911	6.65

LIME.

EUGENE A. SMITH.

DURING the year 1913 there was a falling off in the production of lime in Alabama as compared with the production of the preceding year. The total product of 12 operators in 1913 was 75,468 short tons, a decrease from the 1912 production of 4,489 short tons or 5.61 per cent. The value of the product was $290,394, a decrease of $7,393, or 2.48 per cent.

The most important use of the lime produced is for building purposes. 40.66 per cent of the State's total production is definitely so credited, while of the 48.74 per cent distributed by dealers and uses not specified a large proportion undoubtedly goes for building purposes so that probably 50 per cent or more of the product is thus used. Other chief uses for lime are in chemical works, paper mills, soap factories, sand-lime brick, slag cement, etc.

In the total above given is included hydrated lime produced at two plants only so that exact figures showing this production cannot be given.

Shelby county as heretofore was the largest producer in 1913, having produced 48,953 short tons, or about 65 per cent

of the total. The other producers in the order of their rank were Etowah, Blount, Calhoun and DeKalb.

The following tables present some additional data on the lime production in Alabama in 1912 and 1913:

Production of lime, 1912 and 1913.

	Number of operators	Quantity (short tons)	Rank of State by quantity	Value	Rank of State by value	Average price per ton	Percentage of total U. S. value
1912	13	79,957	14	$297,178	17	$3.72	2.13
1913	12	75,468	16	290,394	16	3.85	1.98
Decrease	....	— 4,489	....	— 6,784	....	....	....
Percentage	....	5.61	....	2.28	....	....	....

Number of lime kilns in Alabama using various kinds of fuel in 1912 and 1913.

Year	Coal	Wood	Coal and Wood	Total Number of Kilns
1912	16	9	27	52
1913	18	0	30	48

Those interested in the subject of lime are referred to an article on lime by Ralph W. Stone of the U. S. Geological Survey, and on the Source, Manufacture, and Use of Lime, by E. F. Burchard and Warren E. Emley of the U. S. Geological Survey, published in Vol. II of the Mineral Resources of the United States for the year 1913.

MICA.

THERE was no production of mica in Alabama during the year 1912, but there was a small production in 1913, but as there was only one producer the figures showing the production cannot be given.

The resources of the State as regards mica are given in the statistical report for 1912. Many important details concerning the production of mica may be found in the Second Volume of Mineral Resources of the United States, in an article by Mr. Douglas B. Sterrett of the U. S. Geological Survey.

MINERAL WATERS.

R. B. DOLE.

RETURNS from Alabama indicate that the mineral-water trade in 1913 was practically the same as in 1912. The sales amounted to 169,687 gallons, or 4,009 gallons more than in 1912, and the value of the output was $19,343, or $1,092 less than in 1912 . The average price reported was 11 cents a gallon, against an average of 12 cents in 1912. Fourteen springs reported sales; one spring active in 1912 was idle in 1913, and one spring's output, which was not reported, was estimated on the basis of the sales in 1912. There was some decrease in the sale of medicinal waters, but an appreciable increase in the sale of table waters, so that trade in the latter found the greater part of the business. Five bathing establishments and resorts accommodating nearly 1,500 guests at 9 springs were maintained. In addition to the quantity reported as sold, 70,000 gallons of mineral water was used in the manufacture of soft drinks.

The following 14 springs reported sales:

Alabama Mineral Springs, McWilliams, Wilcox County.
Bailey Springs, Florence, Lauderdale County.
Bladon Springs, Bladon Springs, Choctaw County.
Blount Springs, Blount Springs, Blount County.
Bromberg Gulf Coast Lithia Spring, Bayou La Batre, Mobile County.
Dixie Spring, Dixie Spring, Walker County.
Healing Springs, Healing Springs, Washington County.
Ingram Lithia Wells, near Ohatchee, Calhoun County.
Livingston Spring Livingston, Sumter County.
Luverne Mineral Spring, Luverne, Crenshaw County.
MacGregor Spring, Spring Hill, Mobile County.
Matchless Mineral Wells, east of Greenville, Butler County.
Purity Spring, Spring Hill, Mobile County.
White Sulphur Wells, near Jackson, Clarke County.

The following table shows the relative productions and their respective values for 1912 and 1913.

Production and value of mineral waters in 1912 and 1913.

	No. of springs reporting	Quantity sold (gallons)	Average retail price	Total value of mineral waters	Percentage of total U. S. value
1912	16	165,678	$0.12	$20,435	0.31
1913	15	169,687	0.11	19,343	0.34
Increase or decrease	— 1	+ 4,009	....	— 1,092	....
Percentage	....	2.42	....	5.34	....

OCHER.

JAMES M. HILL.

OCHER is a hydrated ferric oxide permeating a clay base. It has a specific gravity of about 3.5 and a decidedly golden-yellow color. As viewed under the microscope and with considerable enlargement the particles composing ocher appear flocculent and uniform. Good grades should contain 20 per cent or more of iron oxide, though there is a wide variation in the iron content of the material sold as ocher. Ferruginous shale is often ground and the product marketed as ocher, but unless the material is actually an ocher, as defined above, such product is classed under slate and shale in this chapter.

In 1913 ocher was produced in Georgia, Pennsylvania, Virginia, Alabama, California, Iowa, and Vermont, the States being named in the order of their producing importance. The Georgia output, practically all of which came from the vicinity of Cartersville, Bartow County, was 65 per cent of the total production of the United States. Mines located in Berks, Northampton, and Lehigh counties, Pa., produced a little over 22 per cent of the ocher mined in the country. In Virginia the production was as usual from Page and Pulaski counties. Alabama re-entered the class of ocher producers, a new mine being opened in Clarke County.* The ocher mines of Stanislaus and Calaveras counties, Cal., were worked to a limited extent, and it seems possible, according to trade reports, that the deposits near Michigan Bar, Sacramento County, may be re-opened.

Ocherous clays and true ocher are not unusual in most parts of the country. The Survey is constantly in receipt of samples of yellow material, some of which would undoubtedly make good paints, but many of which are certainly not salable for use as pigments. During the year promising deposits have been opened in Utah, California, and Wisconsin, and several samples have been received from new workings in the old Virginia field.

*There are many promising deposits of ocher in Alabama, especially in the area of the Tuscaloosa formation of the Cretaceous, as well as in other parts of the Coastal Plain southward nearly to the Gulf. E. A. S.

NATURAL GAS.

By B. Hill.

NATURAL gas was produced commercially in Alabama in Fayette, Madison, and Walker counties in 1913, there being a total of 340 domestic and 2 industrial consumers supplied in the towns of Fayette, Jasper, and West Huntsville. Jasper was first supplied with gas in 1913, and this is one of the features that mark the progress of the natural-gas industry in this State. As compared with 1912, the number of consumers supplied in 1913 was more than double, and the income derived from sale of gas was proportionately increased.

Considerable effort has been made and much money spent in trying to find an important oil or gas field in Alabama; the results have not been very encouraging, but the prospectors are hopeful, and the work continues. The gas wells in the Fayette and Walker County fields are holding up very well. The number of productive gas wells in the State at the close of 1913 was 18. One well was flooded and abandoned, but an effort will be made to bring it back, and there is a chance that it may yet be a producer. During 1913 there were 7 dry holes drilled in Alabama, 1 in Fayette County, 1 in Morgan County, 4 in Walker County, and 1 in Winston County.

The depth of the productive gas wells in Alabama varies from 300 to 2,400 feet and the pressure from 25 to 800 pounds.

The statistics of the gas production in this State are included with those of Louisiana.

SAND AND GRAVEL.

THE total production of sand and gravel in the State in 1913 was 1,405,068 short tons valued at $398,008, as compared with 852,943 tons valued at $268,111 in 1912, an increase in quantity of 552,125 tons or 64.73 per cent, and an increase in value of $129,977, or 48.48 per cent.

There was an increase in the quantity of sand of 21,686 short tons or 6.11 per cent, but a decrease in value of $767 or 0.6 per cent.

In the quantity of gravel there was an increase of 106.55 per cent, and in the value, of 92.83 per cent.

Over 76 per cent of the sand was used for building purpose.

The following tables give a comparison of production of sand and gravel in 1912 and 1913, and the production, value and disposition of the sand in these two years.

Productions in short tons of sand and gravel in 1912 and 1913.

	Sand		Gravel		Total*		Percentage of total U. S. value
	Quantity	Value	Quantity	Value	Quantity	Value	
1912	355,111	$127,250	497,832	$140,861	852,948	268,111	1.16
1913	376,797	126,483	1,028,271	271,605	1,405,068	398,088	1.64
Increase or decrease	+21,686	− 767	+ 530,439	+130,744	+ 552,125	+129,977	......
Percentage	6.11	.60	106.55	92.83	64.73	48.48	......

*Chert has been added to these totals.

Production (in short tons), value and kinds of sand in 1912 and 1913.

	Molding Sand		Building Sand		Grinding & Polishing Sand		Paving Sand		Engine Sand		Other Sand		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1912	51,107	$25,284	205,498	$66,586	....	....	37,801	$14,997	45,000	$13,300	15,705	$7,083	355,111	$127,250
1913	57,798	23,368	288,346	90,347	25,903	$11,118	2,750	1,250	....	....	2,000	400	376,797	126,483
Increase or decrease	+6,691	−1,916	+82,848	+23,761	....	....	−35,051	−13,747	....	....	−13,705	−6,683	+21,686	− 767
Percentage	13.09	7.58	40.32	35.69	....	....	92.72	91.67	....	....	87.26	94.35	6.11	.60

STONE.

E. F. BURCHARD.

THE figures presented in the following report have to do with the stone produced and sold by the quarrymen and include only such manufactured product as is put on the market by the quarrymen themselves. This applies especially to rough and dressed building stone, dressed monumental stone, crushed stone, flagstone, curbstone, and paving block. The value given to this manufactured product is the price received by the producer, free on board at point of shipment, and includes therefore the cost of labor necessary to dress the stone. The stone reported as sold rough includes stone sold as rough stock to monumental works, and to cut-stone contractors for building purposes; stone sold as riprap, rubble, and flux; and includes the value of only such labor as is required to get the stone out of the quarry in the shape required by the purchaser. The value given to this stone is the price received by the quarryman free on board at point of shipment. In case the stone is sold to local trade the value is given as the quarryman sells the material, generally at the quarry, but in some cases delivered, if this is done by the producer. In some instances a long haul to market or to the railroad increases the cost of the material, and therefore of the selling price.

PRODUCTION.

BY EUGENE A. SMITH.

Alabama produces commercially only three kinds of stone, namely, limestone, marble, and sandstone.

The total value of production of stone in Alabama showed an increase in 1913 of more than 52 per cent. The greater part of this increase was in the limestone production, $281,579 or 53.01 per cent. The sandstone showed a larger per cent of increase, viz., 447.58, though the increase in actual value was less, viz., $123,515. The value of the marble produced also

increased in a notable way, but exact figures cannot be given since there were less than three producers.

The following table gives some additional details concerning the total stone production.

Total value of stone (limestone, sandstone and marble) produced in Alabama in 1913. Percentage of total U. S. value, rank of State and number of plants.

Year	Total value	Percentage of total U. S. value	Number of plants	Rank of State
1912	$ 842,300	1.08	26	27
1913	1,285,944	1.54	35	20
Increase 1913	443,644			
Percent increase	52.64			

LIMESTONE.

The most important use of the limestone produced in Alabama in 1913 as in 1912 was for furnace flux, while crushed stone for concrete, and stone for riprap follow next in importance. The very great increase in the percentage of crushed stone used for concrete is the most striking feature in the stone production for the year. There was a very decided falling off in the value of the limestone used for paving, and a decrease less pronounced in the crushed stone used for road making and for railroad ballast. For the first time in many years a production of building stone, rough and dressed, is reported, and the use of limestone for agricultural purposes makes a welcome beginning.

The limestone burned into lime or used in the manufacture of Portland cement is not taken account of here, but is included in the value of each of the finished products in whose manufacture it was used.

As thus limited the total value of the limestone produced in 1913 was $812,664, as compared with $531,085 in 1912, an increase of $281,579 or 43.01 per cent.

The values of the limestone produced in 1912 and 1913, classified according to the uses of the stone, are given in the following table:

Value of limestone (not including marble) produced in 1912 and 1913, according to uses.

Use	1912	1913	Increase or Decrease	Percentage
Rough Building	....	$9,517	+ $9,517	....
Dressed Building	....	27,020	+ 27,022	....
Paving	$15,900	189	− 15,711	98.81
Rubble	....	188	+ 188	....
Riprap	81,361	58,850	− 22,511	27.67
Crushed Stone:				
Road making	54,270	47,237	− 7,043	12.98
R. R. ballast	14,093	7,187	− 6,906	49.00
Concrete	26,235	168,195	+141,860	540.73
Flux	339,166	487,078	+147,912	43.61
Agricultural	60	7,203	+ 7,143	....
Total	531,085	812,664	+281,579	53.01

Limestone for Building Purposes.

Eugene A. Smith.

The preparation of cut stone for building purposes in Alabama, while on the increase, is not yet what it should be. Practically all of this material comes from the quarries in the subcarboniferous limestone of the Tennessee Valley, the most important quarries being at Rockwood in Franklin County, operated by Foster-Creighton-Gould Co., of Nashville. This stone is quite similar in appearance, composition, and other qualities to the Indiana stone, and so far as experience in the use of the stone from the two localities in the buildings of the University of Alabama goes, the Alabama stone holds its own under influence of the weather better than does the Indiana stone. Stone steps, door sills, and window sills, buttress caps, etc., of the Alabama stone put in place in 1885 show practically no deterioration in color and wear under foot, and in crumbling and roughening under the influence of the weather, which cannot be said of some portions of the Indiana stone used in buildings erected in 1909-10. The Rockwood quarries have most modern and approved methods of machinery for sawing the stone and handling it in transit

to the mills and elsewhere. The stone is of massive formation, of great thickness and extent. Blocks weighing as much as 25 tons, without crack or flaw, are not infrequently quarried, the size of the blocks being practically limited only by the capacity of the hoisting machinery.

The Oolitic variety is most extensively used for building and monumental work. It is of light gray color, uniform grain, and homogeneous texture. It possesses a quality of cheapness, it can be cut to any design required, and is at the same time strong and durable.

With the installing of adequate machinery at the quarry for doing the finished work, there should never be any longer any reason for going outside of the State for this quality of stone. Already the material has been very extensively used in public buildings in Mississippi, Tennessee, as well as in Alabama. The only reason why it was not used in the recently erected buildings at the University of Alabama was that at the time these building contracts were let, the quarries furnished only the rough sawn stone and there was not in Alabama any establishment adequately equipped for the dressing of the stone in the quantity needed.

MARBLE.

EUGENE A. SMITH.

The marble of Alabama is of two kinds, crystalline or true marble and non-crystalline.

The crystalline or statuary marble occurs mainly in a narrow valley along the western border of the metamorphic area, extending from Marble Valley in Coosa County, through Talladega into Calhoun. The length of the marble belt through Coosa and Talladega counties is about 50 miles. The width of the valley carrying the marble as a rule is from one quarter to one-half mile, widening in places to a mile and a quarter, for example in the neighborhood of Sylacauga.

The quarries longest known are Gantt's and Herd's near Sylacauga, Nix's near Sycamore, Bowie's near Rendalia, and Taylor's and McKenzie's near Taylor's Mill, east of Talladega. From all of these marble was quarried before the civil war.

During 1913 only two companies reported any marble production, viz., the Alabama Marble Company, at Gantt's Quarry and the Moretti-Harrah Company, whose quarry adjoins Gantt's.

The Alabama Marble Quarries of the Scott Brothers near Sycamore and the Eureka Quarry near Talladega Springs are in course of development and will report production in 1914.

The plant of the Alabama Marble Company at Gantt's Quarry which was completely destroyed by fire in December, 1910, has been rebuilt and equipped with all the machinery needed for the working up of any kind of finished product.

I think it is fairly safe to say that on the whole the marble from this quarry and immediate vicinity is of the highest grade of commercial white marble now on the market and obtainable in large quantity. There are small quantities of marble produced both in Italy and Vermont that are somewhat freer from coloring matter than the best grades that can be produced in Alabama in any quantity. But on the other hand, the poorest grades in Alabama greatly surpass the poorest grades produced elsewhere, so that the average of the Alabama deposit is probably somewhat higher than that of any other so far developed, not excluding even the marble from the Carara district in Italy. The marble from this State (Gantt's Quarry) has now a well established reputation and has been used in more than 200 important buildings throughout the United States.

It can be seen in the galleries of the National Museum in Washington.

A beautiful quality of variegated limestone or marble—red, pink and white—belonging probably to the Cambrian formation, occurs in Shelby County a mile or two south of Shelby Springs station on the L. & N. railroad, and extending thence southwest for a mile or two. Nothing but prospecting work has been done on this marble. The Trenton limestone in the Appalachian valleys, particularly Jones Valley below Bessemer, contains marble similar to that quarried in the vicinity of Knoxville, Tenn. Also as to Pratt's ferry on the Cahaba River in Bibb County a quarry was for many years worked in this formation and turned out a very beautiful quality of marble varying in color from gray through pink, red and brown shades.

A black marble which is exceedingly promising, has been reported and some development work done near Anniston, and at Piedmont, Calhoun County, and some very handsome specimens of cave onyx have been obtained from near Kymulga in Talladega County.

In the Coastal Plain the St. Stephens limestone of the Tertiary holds ledges of hard, almost crystalline rock capable of taking good polish. The colors vary from nearly white, through shades of yellowish into red, and it would make a handsome decorative marble, especially for inside work.

Other limestone formations, such as the Subcarboniferous and the Knox Dolomite, could in places be drawn upon for marble.

No figures of production of marble can be given as there were only two companies reporting. The greater part of the product was used for interior decoration.

SANDSTONE.

As may be seen in the tables below, the production of sandstone in 1913 shows a very marked increase in value along every line and particularly in the crushed stone used in concrete. The total value of the sandstone production of 1913 was $151,111, as compared with $27,596 in 1912, an increase of $123,515, or 629.1 per cent.

Value of sandstone production in Alabama from 1909 to 1913.

Year	1909	1910	1911	1912	1913
Value	$77,827	$109,068	$78,195	$27,596	$151,111

Value of sandstone production in Alabama in 1912 and 1913, according to uses.

Uses	1912	1913	Increase or Decrease	Percentage
Rough Building	....	$37,500	+$37,500	....
Ganister	$45	....	— 45	....
Rubble	$4,866	9,055	+ 4,189	86.09
Riprap	10,685	17,056	+ 6,371	59.62
Crushed Stone:—Concrete	12,000	87,500	+ 75,500	629.17
Total	27,596	151,111	+123,515	447.58

SUMMARY.

BECAUSE of the difference in the units of measurement employed in the various branches of the mineral industry, a summation of the production of the year can include only the values of the products. It is also to be noted that a simple summation of all the values of the minerals or mineral products listed in this pamphlet would give a value much in excess of the true value, since in many cases, as, for instance, coal and coke, and iron ore and pig iron and steel, the second product is directly a product of the first, and the value of the first is included in that of the second. To give the values of both as a part of the total would be to repeat, in a measure, at least a partial value of the first or raw product, and would give an erroneous result.

As the Survey has not, however, the figures upon which to base an estimate as to the percentage of each product which was used in the manufacture of some other product, the summation of the mineral production of the State, as given here, will be a simple summation of the values reached by the individual branches of the industry.

According to this rather unsatisfactory manner of summation, which does not include the value of the steel produced, the value of the 1913 raw mineral and immediately derived products was $67,530,089, as compared with $60,141,793 in 1912, an increase of $7,388,296, or 12.28 per cent. This production may be classified as follows:

Raw products	$34,660,545
Pig iron	28,242,374
Coke	9,627 170
Total	67,530,089

The more important mineral products after coal, pig iron and coke, in the order of their value, are iron ores, clay products, stone, cement, sand and gravel, and lime.

Below is a tabular presentation of the value of the mineral productions as estimated above for 1910, 1911, 1912 and 1913:

Total value of the mineral production and products in Alabama in 1910, 1911, 1912, and 1913.

Year	Value
1910	$63,207,945
1911	52,772,951
1912	60,141,793
1913	67,530,089

1916

GEOLOGICAL SURVEY OF ALABAMA

EUGENE ALLEN SMITH, *State Geologist*

BULLETIN No. 16.

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1914

COMPILED FROM MINERAL RESOURCES OF THE UNITED STATES

By
EUGENE A. SMITH

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UNIVERSITY, ALABAMA
1915

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PRESS
BROWN PRINTING CO
MONTGOMERY
ALABAMA

LETTER OF TRANSMITTAL.

UNIVERSITY, ALA., December, 1915.

HON. CHARLES HENDERSON,
Governor of Alabama,
Montgomery, Ala.

SIR:—I have the honor to transmit herewith the manuscript of a Report on the Mineral Production of Alabama for the year 1914 with the request that it be printed as Bulletin No. 16 of the Geological Survey of Alabama.

Very respectfully,

EUGENE A. SMITH,
State Geologist.

GEOLOGICAL CORPS.

Eugene Allen Smith, Ph. D.	State Geologist
William F. Prouty, Ph. D.	Chief Assistant
Robert S. Hodges	Chemist
Herbert H. Smith	Curator of Museum
Roland M. Harper, Ph. D.	Botanist
A. T. Donoho	Stenographer
Geo. N. Brewer	Field Assistant

RIVER GAGE HEIGHT OBSERVERS.

C. J. Stowe	Jacksons' Gap, Tallapoosa River
J. E. Whitehead	Riverside, Coosa River
S. T. Dillard	Beck, Conecuh River
Ed. Bullen	Red Bay, Big Bear Creek

From the records of daily observations of the gage readings at these places when extended through sufficient time, the calculations of available horsepower to be obtained from the different streams is made.

TABLE OF CONTENTS.

PREFACE.

The statistics of all the minerals included in the following pages have been collected in cooperation with the United States Geological Survey, and have been compiled from advance chapters of the *Mineral Resources of the United States,* a publication of the Federal Survey.

The introductory and general matter in each of these articles has either been taken without change from the U. S. advance chapters or has been rearranged or condensed from these chapters, or entirely rewritten to suit it for our present purposes. In each case credit is given to the author.

INTRODUCTION.

EUGENE A. SMITH

AN INSPECTION of the subjoined table will show that there has been a decided decrease in the value of all the mineral products of Alabama in 1914 except cement, gold and silver, graphite and stone, (including marble). The statistics also show that there has been a corresponding decrease in the value of the mineral products of the United States as a whole.

In Bulletin No. 15 of the Alabama Geological Survey,—Statistics of Mineral Production in the State in 1913,—there is an admirable general discussion by Mr. E. W. Parker of the U. S. Geological Survey, of the Mineral Production of Alabama from the early days to the year 1913, along with specific details of the production in 1912 and 1913.

Following the plan thus set out by Mr. Parker, we pass in review the production in 1913 and 1914 of Alabama minerals and their immediate derived products, taking them up somewhat in the order of their commercial importance.

Coal.—Alabama's production of coal in 1914 was 15,593,422 short tons, valued at $20,849,919, a decrease of 11.8 per cent in quantity and 9.68 per cent in value in 1914 as compared with 1913. As in 1913 the value of the coal product of Alabama in 1914 is approximately two-thirds that of the total mineral output.

Coke.—The coke production of Alabama decreased from 3,323,664 short tons valued at $9,627,170 in 1913, to 3,084,149 tons valued at $8,408,443 in 1914, a decrease in value of $1,-218,727 or 12.66 per cent.

Iron Ore and Pig Iron.—While there was in 1914 a decrease of 7.22 per cent in quantity of the total iron ore production, and of 10.71 per cent in the quantity of the Hematite, there was an increase in the quantity of brown ore, of 10.83 per cent. In the quantity of pig iron marketed in Alabama in 1914 there was a decrease from 1913 of 13.68 per cent and a decrease in the value of 24.78 per cent.

The value of this iron ore production and not the value of the pig iron is used in making up the total value of the mineral products of the State.

The total value of the mineral production of Alabama, excluding the value of the pig iron and coke and including the value of the iron ores, was $30,879,288 in 1914, compared with 34,660,545 in 1913, of which, as already stated, approximately two-thirds is represented by the output of the coal mines. Nearly one-fifth of the total value was contributed by the iron mines. The decrease in 1914 from 1913 was $3,781,257, or 10.9 per cent.

The principal coal producing counties are Jefferson, Walker, Bibb, Tuscaloosa and St. Clair in the order named. The principal iron ore counties are Jefferson, Tuscaloosa, Franklin and Etowah. The combined value of the pig iron and coke made in Alabama approximates $26,000.00. These values are not included in the total as they are represented in the value of the iron ore and coal produced.

Clay-Working Industries.—These industries yielded products in 1914, valued at $1,574,023 against $2,091,581, in 1913, a decrease of $17,558, or nearly 25 per cent. This does not include the value of the raw clay sold, which in 1914 amounted to $34,607, a decrease from 1913 of 35.03 per cent.

The center of the clay-working industry is Jefferson county, and Birmingham furnishes the principal market. Vitrified, front and fire brick represent a value of $495,398 or 77.7 per cent of the value of the common brick, while the total output of the brick yards makes up over 72 per cent of the State's total clay products. All of the fire brick is reported from Jefferson county and all of the vitrified brick is from Jefferson and St. Clair counties. Clay pits for the manufacture of common brick have been opened in one or more places in 30 different counties.

Stone.—The quarry products, the larger part of which is limestone, were valued in 1914 at $1,319,753, an increase of 2.63 per cent from $1,285,944 in 1913.

The increased production in 1914 was in the output of limestone for rough building stone, road making, concrete and for agricultural purposes; for sandstone used in Government works on the Warrior River, and the production of marble.

Over 87 per cent of the total value of the stone production is limestone. Its most important uses are for furnace flux, concrete, road making, for building purposes and for agricultural uses. While heretofore comparatively little of the Ala-

bama limestone was used for building purposes, there has been in 1914 a remarkable increase, 119.5 per cent along this line. In the production of marble there has also been a notable increase in 1914. The reader is referred to the body of this Bulletin under Stone for further details concerning especially the building stone and marble industries.

Marble holds the second place in the value of quarry products, a beautiful white marble occurring in Coosa and Talladega counties being extensively used for building (both inside and outside work), and a black marble which gives promise of future development, has been prospected near Anniston and near Piedmont.

Cement.—The cement production of Alabama amounted in 1914 to 777,698 barrels, valued at $746,555, as against 823,246 barrels in 1913 valued at $685,422, a decrease of 5.53 per cent in quantity but an increase in value of 8.92 per cent.

Lime.—The lime production is not included in that of the limestone, and amounted to 46,966 short tons, a decrease from 1913 production of 28,502 short tons, or 37.77 per cent. The value of the product was $199,814, a decrease of $90,580 or 31.19 per cent.

Graphite.—The Alabama graphite is all of the crystalline variety, and the value of the product in 1914 was $118,000 as against $87,336 in 1913, an increase of 35.88 per cent. The Alabama production for 1914 was 41.35 per cent of the total value of the crystalline graphite produced in the United States, and 36.46 per cent of the total value of amorphous and crystalline combined. The great increase in production in 1914, and the installing of a number of new plants, not in active operation during 1914, makes it probable that the Alabama production in 1915 and following years will represent an even larger proportion of the U. S. total value.

Minor Products.—Alabama produces a small quantity of gold and silver, and other minor products are bauxite, mica, millstones, mineral paints, (natural pigments), mineral waters, natural gas, and sand and gravel.

In the following table is presented a comparison of the mineral output of Alabama in 1913 and 1914. As stated above, the total does not include the value of pig iron or that of coke, but it does include the value of the coal made into coke and of the iron ore sold or used.

Mineral production of Alabama in 1913 and 1914.

	1913				1914			
	Raw		Derived		Raw		Derived	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Barytes, short tons					*	*		
Bauxite, long tons	*	*			*	*		
Cement, barrels			828,246	$685,422		†	777,698	$746,555
Clay products, short tons	49,901	$53,419		2,091,581	27,978	$84,607		1,574,028
Coal, short tons	17,678,522	28,083,724			15,593,422	20,849,919		
Coke, short tons			3,823,664	†9,627,170			3,084,149	†8,408,448
Ferro alloys, long tons							* †	* †
Gold, fine ounces (troy)			537	11,094			579	11,970
Graphite, crystalline, pounds	2,020,910	87,336			2,410,200	118,000		
Iron ore, long tons	5,333,218	6,648,569			4,514,926	5,727,619		
Iron, pig, long tons			1,924,762	†23,242,374			1,661,420	†17,481,828
Lime, short tons			75,468	290,394			46,966	199,314
Mica				*				*
Millstones				*				*
Mineral paints, natural pigments, short tons			*	*			*	*
Mineral waters, gallons sold	169,687	19,848			169,279	17,125		
Natural gas		*				*		
Sand and gravel, short tons	1,405,068	398,088			881,480	262,219		
Silver, fine ounces (troy)			117	71			199	110
Stone		‡		‡1,285,944		‡		‡1,319,758
Miscellaneous		46,618		12,361		42,382		336,325
Total value, eliminating duplications	$84,660,545				$30,879,288			

* Value included under "Miscellaneous." † Value not included in total value. ‡ Stone sold rough included in derived products.

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1914.

ABRASIVES.

EUGENE A. SMITH.

ALABAMA'S production of abrasives is at present limited to a small number of millstones (chasers*) quarried and made at Dutton, Jackson County; there are, however, several materials in different parts of the State which are sufficiently promising to be worth investigation and thorough testing; the nature and locality of these deposits were treated in Bulletin No. 13, which see.

BARYTES.

JAMES M. HILL.

There has been no production of barytes in Alabama since 1906 until 1914, when a small production is reported from Calhoun county. There are other deposits which probably could be worked with profit in Etowah, St. Clair and Bibb counties.

The residual deposits so far worked are associated with the Chickamauga ("Pelham") limestone, of Ordovician age, and the Knox dolomite, of Cambrian and Ordovician age. They

*Chasers are larger than the regular millstones. They are used for heavier work, such as grinding quartz, feldspar, barytes, etc., and they run on edge. Though they are made with a diameter as short as 24 inches, they are usually turned out with diameters ranging from 50 to 84 inches, and are as much as 22 inches in thickness. These chasers are run on pans paved with roughly cubical blocks of the conglomerate, with edges about a foot in length. In grinding quartz in such pans the chasers are used in the preliminary crushing; then rough blocks, usually three in number, are either attached to or carried along by lateral arms, which in turn are joined to a vertical revolving shaft. By the circular movement of these blocks the material placed in the pan is ground to powder.

There were 14 operators in New York in 1912. One quarry was reported idle during the year and one former operator has gone out of business.—Frank J. Katz.

seem to be localized along lines of folding and faulting of the rocks, particularly along the eastern side of the Appalachian fold. The barytes probably occurred originally as veins and replacements along fissured or fractured dolomite. Solution of the dolomite has left the insoluble barium sulphate in nodules and bowlders in the residual clay.

Character of Barytes.

Barytes, or heavy spar ($BaSO_4$), is composed of 65.7 per cent barium oxide (BaO) and 34.3 per cent of sulphur trixoide (SO_3). The specific gravity of the mineral ranges from 4.3 to 4.6; its hardness varies from 2.5 to 3.5. It is usually a white opaque to translucent crystalline mineral about as hard as calcite, but it differs from calcite in its greater specific gravity and in the fact that it is perfectly inert when treated with acids. Some barytes is stained reddish pink or yellow by iron oxide. In its common form it is an aggregate of straight or slightly curved cleavable plates, but it occurs also in granular, fibrous, and earthy masses, and in the form of stalactites, as well as in single and clustered crystals. Natural barytes is rarely pure, its most common impurities being silicia, lime, magnesia, and the oxides of iron and aluminum. Fine particles of galena are disseminated through many of the deposits in the United States. The commercial grades of the mineral as mined carry 95 to 98 per cent barium sulphate and 1 to 3 per cent of silica.

Uses of Barytes.

Barytes is used principally as a pigment in mixed paints, in the manufacture of lithopone—a chemically prepared white pigment consisting of zinc sulphide and barium sulphate—and as a base upon which the lake pigments are precipitated. It is also used in the manufacture of white rubber goods, asbestos cement, and artificial ivory, and in the preparation of fertilizers, boiler compounds, insecticides, peroxide of hydrogen, and artificial driftwood salts. Barium carbonate and some barium chloride are used to prevent efflorescence on bricks; and the carbonate, sulphate, or nitrate is used in the manufacture of rolled glass, hollow glass, crystal and table glass, and in special glasses such as the Jena phosphate crown glass.

BAUXITE.

The production of bauxite in Alabama for 1914 was limited to one producer, which accounts for the decrease and also for the joining of the Alabama and Georgia totals.

The following table gives the production and value of bauxite from 1889 to 1914, inclusive:

Production of bauxite in the United States, 1889-1914, by States, in long tons.

<table>
<tr><th>Year</th><th>Georgia</th><th>Alabama</th><th>Arkansas</th><th>Total</th><th>Value</th></tr>
<tr><td>1889</td><td>728</td><td>.........</td><td>.........</td><td>728</td><td>$2,866</td></tr>
<tr><td>1890</td><td>1,844</td><td>.........</td><td>.........</td><td>1,844</td><td>6,012</td></tr>
<tr><td>1891</td><td>3,301</td><td>292</td><td>.........</td><td>3,593</td><td>11,675</td></tr>
<tr><td>1892</td><td>5,110</td><td>5,408</td><td>.........</td><td>10,518</td><td>34,183</td></tr>
<tr><td>1893</td><td>2,415</td><td>6,764</td><td>.........</td><td>9,179</td><td>29,507</td></tr>
<tr><td>1894</td><td>2,050</td><td>9,016</td><td>.........</td><td>11,066</td><td>35,818</td></tr>
<tr><td>1895</td><td>3,756</td><td>13,313</td><td>.........</td><td>17,069</td><td>44,000</td></tr>
<tr><td>1896</td><td>7,313</td><td>11,051</td><td>.........</td><td>18,364</td><td>47,338</td></tr>
<tr><td>1897</td><td>7,507</td><td>13,083</td><td>.........</td><td>20,590</td><td>57,652</td></tr>
<tr><td>1898</td><td>.........</td><td>.........</td><td>.........</td><td>25,149</td><td>75,437</td></tr>
<tr><td>1899</td><td>15,736</td><td>14,499</td><td>5,045</td><td>35,280</td><td>125,598</td></tr>
<tr><td>1900</td><td colspan="2">19,739</td><td>3,445</td><td>23,184</td><td>89,676</td></tr>
<tr><td>1901</td><td colspan="2">18,038</td><td>867</td><td>18,905</td><td>79,914</td></tr>
<tr><td>1902</td><td colspan="2">22,677</td><td>4,645</td><td>27,322</td><td>120,366</td></tr>
<tr><td>1903</td><td colspan="2">22,374</td><td>25,713</td><td>48,087</td><td>171,306</td></tr>
<tr><td>1904</td><td colspan="2">21,913</td><td>25,748</td><td>47,661</td><td>235,704</td></tr>
<tr><td>1905</td><td colspan="2">15,173</td><td>32,956</td><td>48,129</td><td>240,292</td></tr>
<tr><td>1906</td><td colspan="2">25,065</td><td>50,267</td><td>75,332</td><td>368,311</td></tr>
<tr><td>1907</td><td colspan="2">.........</td><td>.........</td><td>*97,776</td><td>480,330</td></tr>
<tr><td>1908</td><td colspan="2">14,464</td><td>*37,703</td><td>52,167</td><td>263,968</td></tr>
<tr><td>1909</td><td colspan="2">22,227</td><td>*106,874</td><td>129,101</td><td>679,447</td></tr>
<tr><td>1910</td><td colspan="2">33,096</td><td>*115,836</td><td>148,932</td><td>716,258</td></tr>
<tr><td>1911</td><td colspan="2">30,170</td><td>*125,448</td><td>155,618</td><td>750,649</td></tr>
<tr><td>1912</td><td>19,587</td><td>14,173</td><td>*126,105</td><td>159,865</td><td>768,932</td></tr>
<tr><td>1913</td><td colspan="2">27,409</td><td>*182,832</td><td>210,241</td><td>997,698</td></tr>
<tr><td>1914</td><td colspan="2">18,547</td><td>200,771</td><td>219,318</td><td>1,069,194</td></tr>
</table>

*Production of Tennessee included.

For an outline of the uses of bauxite, see Bulletin No. 13.

The Republic Mining & Manufacturing Co. was the only one that operated in Alabama in 1914. The company worked near Rock Run, Cherokee County, in the eastern part of the State.

CEMENT.

EUGENE A. SMITH.
E. F. BURCHARD.

PUZZOLAN OR SLAG CEMENT.

DURING the past six years only one establishment in Alabama has been engaged in the manufacture of slag cement, using the material from the furnaces about Birmingham. The production is included in the returns for Portland cement and cannot be given separately.

PORTLAND CEMENT.

RESOURCES.

Alabama contains large supplies of limestone, chalk, clay and shale well adapted for Portland Cement manufacture, and widely distributed throughout the State. Coal and labor are abundant and cheap, transportation facilities are excellent, and many of the best limestone and chalk localities are situated on navigable rivers, giving ready access and cheap water transportation to Galveston, New Orleans, Mobile, Charleston, and other ports of the Gulf and Atlantic Coasts. This advantage of location was immensely increased with the opening of the Panama Canal for cement plants located in Alabama are more than a thousand miles nearer to the Isthmus than their nearest possible competitors.

The limestones and shales of the northern part of the State lie so close to each other, and above all so close to the great coal mines which must supply the fuel, that the establishment of Portland Cement plants near the coal mines would give to this industry in Alabama the same advantages which the proximity of the iron ore, the coal, and the stone has given to the iron industry, and which has placed our State beyond competition.

As a Portland cement mixture, ready for burning, consists approximately of 75 per cent lime carbonate and 25 per cent of clayey matter, the material furnishing the lime carbonate is necessarily of more economic importance than that from

which the silica and alumina are derived. In consequence, a Portland cement plant is usually located in the immediate vicinity of a suitable limestone, while the clay or shale required to complete the mixture may be brought some distance.

The limestone formations in North Alabama which can supply the stone adapted for use in cement manufacture are the Trenton or Pelham limestone and the Bangor or Subcarboniferous. In close proximity to both these limestone formations are the shales of the Clinton, Subcarboniferous and Coal Measures.

At the present time there are two cement plants in North Alabama, namely, the Standard Portland Cement Co., located at Leeds in Jefferson County, and the Atlantic & Gulf Portland Cement Co., located at Ragland in St. Clair County. Both of these plants make use of the hard Trenton limestone, and the Standard Cement Co., according to Burchard of the U. S. Geological Survey, uses the shale of the Clinton formation whilst the Ragland Company makes use of the shales of the Coal Measures. Up to the present time no establishment is utilizing the Bangor limestone.

In Middle Alabama the soft, chalky Cretaceous limestone of the Selma Chalk, is the material utilized by the Alabama Portland Cement Co., at Spocari, near Demopolis. The same Company makes use of residual clays overlying and derived from the weathering of the Selma Chalk. During 1914 there was no production reported from the Demopolis plant.

In Southern Alabama the St. Stephens limestone outcropping east and west across the State, furnishes excellent material for Portland Cement manufacture, using either residual clays from decomposition of the limestone, or the clays of the Grand Gulf formation which are almost everywhere in close proximity to the limestone*

The following tables summarize the number of active plants in the United States, and the production of puzzolan cement during the last five years; and the production and value of cement (including puzzolan and Portland) in Alabama in 1913 and 1914:

*Since recent investigations (quoted by Burchard), have shown that limestones containing as much as 10 per cent of magnesia, (MgO), may be used in the manufacture of Portland cement, without detriment to the quality of the cement, the quantity of limestone in Alabama suitable for this manufacture is very greatly increased, over former estimates.—E. A. S.

Statistics of the puzzolan cement industry, 1910-1914.

	1910	1911	1912	1913	1914
Number of plants reporting production:					
Alabama	1	1	1	1	1
Indiana	0	0	0	0	1
New York*	....	1	1	1	1
Ohio	2	1	1	1	1
Pennsylvania	1	1	1	1	1
Total	4	4	4	4	5
Production in barrels of 330 pounds	95,951	93,230	91,864	107,313	68,311
Value of production	$63,286	$77,786	$77,363	$97,663	$63,358

*Includes production of Collos cement in 1911, 1912, and 1913.

Owing to the fact that there was in Alabama in 1914 only one producer of puzzolan cement, and not more than two operating plants in the Portland cement industry, it is necessary to combine the productions of the two industries in order to avoid publishing figures which were given to the survey in confidence. The tabular results of such a combination are, however, necessarily inconsistent and not to be taken too literally, since the weights per barrel of the two kinds of cement vary.

The total quantity of Portland and puzzolan cement produced in Alabama in 1914 was 777,698 barrels, valued at $746,555, as compared with 823,246 barrels in 1913, valued at $685,422, or a decrease in the production of 45,548 barrels, or 5.53 per cent, but an increase in value of $61,233, or 8.92 per cent.

Below are presented in tabular form the foregoing figures:

Production and value of cement (including puzzolan and Portland) in Alabama in 1913 and 1914.

	No. of Producers	Quantity (Bbls.)	Value	Percentage of total U. S. Value
1913	3	823,246	$685,422	0.74
1914	3	777,698	746,555	0.93
Decrease and increase	....	—45,548	+61,133	....
Percent. of increase and decrease	....	—5.53	+8.92	....

In "Mineral Resources of the United States, for 1914, Part II, (pages 221-259)," the reader, who is interested in the subject, will find a very complete presentation of the cement industries of the United States, by Mr. E. F. Burchard of the U. S. Geological Survey.

CLAY AND CLAY PRODUCTS.

JEFFERSON MIDDLETON AND EUGENE A. SMITH.

CLAY.

CLAY available for the manufacture of clay products is one of the most widely distributed of our minerals. Hence there are clay-working plants scattered over every State and Territory in the Union. Miners of the lower-grade clays are usually also the manufacturers, but as the higher grades of ware are reached, the rule is that fewer and fewer manufacturers are also miners, until in the highest grades of ware the rule is that the manufacturer buys and does not mine the clay he uses. The figures given in the following tables represent clay that is mined and not manufactured by the miner, but is sold as clay. The clay thus sold is small in quantity compared with the total production and includes mainly clay used for high-grade pottery and tile, for paper making, and for refractory products.

The total amount of clay mined in Alabama and sold as such in 1914 was 27,973 short tons, valued at $34,607. This was a decrease in quantity of 21,928 tons, or 43.93 per cent, and of $18,662, or 35.03 per cent in value as compared with 1913.

Below is a table giving the production and value of clay mined and sold in Alabama from 1908 to 1914 inclusive, and a comparison of the production of 1913 and 1914.

Production of clay in Alabama from 1908 to 1914 inclusive, and a comparison of the production in 1913 and 1914.

YEAR	Fire Clay		Miscellaneous Clay		Total	
	Quantity Short Tons	Value	Quantity Short Tons	Value	Quantity Short Tons	Value
1908	68,289	$48,988	24,000	$12,000	92,289	$60,988
1909	45,137	35,345	18,271	5,587	63,408	40,932
1910	54,482	32,395	20,600	5,650	75,082	38,045
1911	35,203	29,909			35,203	29,909
1912	38,552	31,414	4,500	2,000	43,052	33,414
1913	49,901	53,269	*	*	49,901	53,419
1914	27,973	34,607			27,973	34,607
Decrease 1914	21,928	18,662			21,928	18,812
Percentage of Decrease	43.93	35.03			43.93	35.21

*Not divulged but included in total.

In 1913 the average value of fire clay was $1.07 per short ton and the fire clay production of Alabama represented 1.21 per cent of the total value of the United States production. In 1914 the average value of Alabama fire clay was $1.22 per short ton, and the value of the Alabama product was 0.92 per cent of the total value of the fire clay produced in the United States.

CLAY WORKING INDUSTRIES.

ALABAMA, like others of the Southern States, is rich in clays, but its rank as a clay-working State is not very high. In 1914 it was twentieth among the States, with products valued at $1,574,023, or less than 1 per cent of the total. This was a decrease of $517,558, or nearly 25 per cent from 1913. Alabama was tenth in the production and value of vitrified paving brick. The principal product was common brick, valued in 1914 at $638,666 and representing 40.58 per cent of the value of all of Alabama's clay products in that year.

Jefferson County was the principal clay-working county, reporting a production valued at $1,029,135, or 65.38 per cent of the total value for the State in 1914, a decrease of $284,297 from 1913. Nearly all of the fire brick produced in the State comes from Jefferson County and fire brick and vitrified brick are its principal clay products. The leading counties in the value of common brick in 1914 were, in the order of their importance, Jefferson, Montgomery, Russell, and Talladega.

Clay products of Alabama, 1910-1914.

Product.	1910	1911	1912	1913	1914
Brick:					
Common—					
Quantity	135,785,000	129,694,000	136,989,000	130,928,000	110,781,000
Value	$746,961	$708,903	$759,409	$730,148	$638,666
Average per M	$5.50	$5.47	$5.54	$5.58	$5.77
Vitrified—					
Quantity	19,772,000	21,444,000	26,480,000	24,183,000	18,679,000
Value	$236,516	$246,707	$353,303	$361,722	$248,525
Average per M	$11.96	$11.50	$13.34	$14.96	$13.31
Front—					
Quantity	(*)	9,169,000	10,629,000	(*)	(*)
Value	(*)	$128,403	$132,083	(*)	(*)
Average per M	$15.96	$14.00	$12.42	$15.29	$11.42
Fancy, value	....	(*)	(*)	....	(*)
Fire, value	$163,672	$193,375	$240,484	(*)	$167,021
Draintile, value	$3,773	$3,777	$5,465	$10,802	$6,838
Sewer pipe, value	(*)	(*)	(*)	(*)	(*)
Fireproofing, value	(*)	(*)	(*)	(*)	(*)
Tile, not drain, value	....	....	....	(*)	....
Pottery:					
Red earthenware, value	$3,475	$11,243	$10,990	$11,164	$4,800
Stoneware and yellow and Rockingham ware, value	$16,371	$14,753	$11,228	$8,994	$11,742
Miscellaneous, value	$496,791	$639,941	$422,322	$968,751	$496,431
Total value	$1,667,559	$1,947,102	$1,935,179	$2,091,581	$1,574,023
Number of active firms reporting	87	82	74	68	70
Rank of State	22	17	17	16	20

*Included in "Miscellaneous."

BRICK AND TILE.

THE total production of common brick in Alabama in 1914 was 110,731 M, valued at $638,666. This as compared with the 1913 production, represents a decrease in both quantity and value, of 20,192 M or 15.34 per cent, and of $91,482, or 12.53 per cent, respectively.

In the case of vitrified brick there was also a decrease in quantity of 5,504 M, or 22.76 per cent, and in value of $113,197 or 31.29 per cent.

In 1913 the number of producers of fire-brick in Alabama fell below 3, and the quantity and value could not be disclosed. In 1914, however, the production was 8,721 M, valued at $167,021.

The following table gives a review of the brick and tile industry in Alabama for 1913 and 1914.

Production of brick and tile in Alabama in 1914, not including pottery products.

Kind	Quantity per Thousand	Value	Average Value per Thousand	Percentage of total value of brick and tile	Percentage of total U. S. value
Common brick	110,731	$638,666	$5.77	41.01	1.45
Vitrified Brick	18,679	248,525	$13.31	15.96	1.98
Drain Tile		6,838		0.43	.08
Fire Brick	8,721	$167,021	$19.15	10.73	1.01
Miscellaneous		*496,431		31.87	
Total		$1,557,481		100.00	1.20

*Includes front brick, fancy brick, sewer pipe, fire-proofing, and silica brick.

Brick and tile production in 1913 and 1914 compared.

Kind	1913			1914			Increase or Decrease in Value	Percentage
	Quantity M	Value	Average Price	Quantity M	Value	Average Price		
Common Brick	130,923	$730,148	$5.58	110,731	$638,666	$5.77	— $91,482	12.53
Vitrified Brick	24,183	361,722	14.96	18,679	248,525	13.31	—$113,197	31.29
Front Brick	*	*	15.29	*	*	*11.42		
Fire Brick	*			8,721	$167,021	19.15		
Drain Tile		10,802			6,838		— $3,964	36.69
Miscellaneous		†968,751			†496,431			

*Included in Miscellaneous.
†Includes front brick, fancy brick, sewer pipe, fire proofing, and silica brick.

POTTERIES.

THE pottery industry of Alabama is of relatively small importance, as only the commoner and coarser grades of ware are produced and most of this for local trade only.

Production was reported for 1914 by 13 operators, an increase of 4. The output was valued at $16,542, a decrease of $3,616 or 17.94 per cent. The products consisted of red earthen ware and stone ware only. The rank of Alabama in this industry for 1914 is 19.

The following tables show the values of the pottery product in 1914 and a comparison of the production and values for the years 1913 and 1914.

Value of pottery products in 1914.

Kind	Value	Percentage of total Alabama Pottery's Products	Percentage of total U. S. Value
Red Earthenware	$4,800	29.02	.45
Stoneware and Rockingham ware	$11,742	70.98	.35
Total	$16,542	100.00	.05

Comparison of pottery products in 1913 and 1914.

Kind	1913	1914	Increase+ or Decrease—	Per-cent-age
Red Earthenware	$11,164	$4,800	—$6,364	57.00
Stoneware and Rockingham ware	8,994	11,742	+ 2,748	30.55
Total	$20,158	$16,542	--$3,616	17.94

COAL.

E. W. PARKER AND C. E. LESHER.

INTRODUCTORY.

THE great Appalachian coal region which furnishes over two-thirds of the coal production of the United States and which extends from Ohio and Pennsylvania on the north in a gradually narrowing belt through eastern Kentucky and Tennessee has its southern terminus in a considerably broadened area that occupies a large part of the northern half of Alabama. The coal-bearing formations of Alabama underlie about 8,400 square miles and are divided into four distinct basins, the Coosa, the Cahaba, and the Warrior, named from the rivers which drain them, and the Plateau, which includes Blount, Lookout, and Sand or Raccoon Mountains. By far the most important basin in area and in production in the Warrior, which includes all of Walker County, most of Jefferson, Tuscaloosa, and Fayette counties, and smaller parts of Blount, Cullman, Winston and Marion counties. The area known to contain coal is approximately 4,000 square miles, or one-half the total coal area of the State, and contributes about 81 per cent. of the total production.

There are several distinct coal groups in the basin, the most important of which are the Brookwood, the Pratt, and the Mary Lee, designated by the names of their principal beds. The Mary Lee group includes the Blue Creek, the Jagger, and the Newcastle beds, most of which are mined in places. The Brookwood, the Pratt, and the Mary Lee produce most of the coking coal mined in the State, and more than half of all of the coal mined in the district.

The Cahaba Basin, second in importance, is a long narrow syncline, 68 miles long and about 6 miles wide, southeast of the Warrior, and occupies parts of St. Clair, Jefferson, Shelby, and Bibb counties. There are many workable beds, and the total quantity of coal in the basin is large. The production is something over 18 per cent of the total for the State.

The Coosa Basin is a deep syncline east of the Cahaba and parallel with it, extending across Shelby and St. Clair counties. It is also long and narrow, 60 miles long by 6 miles wide. It has not been thoroughly explored, but in different parts of the area from two to twelve beds, 3 or more feet in thickness, have been reported.

The Plateau field embraces parts of Blount, Etowah, DeKalb, Cherokee, Marshall, and Jackson counties, and although it has an area underlain by coal four times that of the Cahaba and the Coosa combined, the resources in Alabama are comparatively small. There are four to six beds locally workable. So far as known, the earliest record of the existence of coal in Alabama was made in 1834. The first statement of production in the State is contained in the United States census report for 1840, in which year the production is given as 946 tons. The census report for 1850 does not mention any coal production for the State, and the next authentic record is contained in the census statistics of 1860, when Alabama is credited with an output of 10,200 short tons. The mines of Alabama were probably worked to a considerable extent during the Civil War, but there are no records of the actual production until 1870, for which year the United States census reports a production of 11,000 tons. Ten years later the production had increased to 323,972 short tons, but the development of the present great industry really began in 1881 and 1882, when attention was directed to the large iron deposits near the city of Birmingham

and thus the great "boom" of that city and vicinity was inaugurated. By 1885 the coal production of the State had increased to nearly 2,500,000 tons. Then followed a period of relapse and liquidation, which lasted two years, after which business settled down to a conservative and rational basis and has since developed steadily. In 1902 the coal production of the State reached a total of more than 10,000,000 tons, and reached the maximum of 17,678,522 tons in 1913.

PRODUCTION.

Total production in 1914, 15,593,422 short tons; spot value, $20,849,919.

The coal production of Alabama decreased 2,085,100 tons, or 11.8 per cent, in quantity and $2,233,805, or 9.68 per cent, in value in 1914, compared with 1913. The decrease was general throughout the State, only a few counties showing a slight increase. The decrease is attributed to a number of causes, the principal one being the general business depression, which was felt particularly in Alabama because of its importance as an iron-making State, and because the iron interests more than any other branch of the mining industry suffered from the unsatisfactory trade condition. In addition to the demoralization in the iron trade, the disturbed situation in Mexico, resulted in a loss of market for Alabama coke. Alabama coal was also affected by the low price of petroleum in the Southwestern States; by increased water-power development; by the competition of coal from Kentucky and Illinois in the markets of Louisiana and Mississippi, which are normally supplied by Alabama; and by the smaller bunker trade resulting from the cessation of exports of cotton after the declaration of war in Europe. There was a plentiful supply of labor for coal-mining operations throughout the year, and no shortage of cars for transportation and no serious labor troubles were reported.

The average output of coal per man showed a decrease from 720 tons in 1913 to 649 tons in 1914, but there was a slight increase in the average output per man per day, from 2.82 tons in 1913 to 2.87 tons in 1914. The number of men employed in 1914 was 24,042, who worked an average of 226 days in the year, as compared with 24,552 men in 1913, who worked 255

days. There was a considerable increase in the quantity and percentage of coal mined by machines. In 1914 the machine-mined output increased from 4,124,301 tons, or 23.3 per cent, in 1913, to 4,937.222 tons, or 31.7 per cent. The number of machines in use, however, decreased from a total of 377 in 1913 to 362 in 1914. Of the latter, 223 were punchers, 88 short wall, 31 chain breast, and 20 long wall. The powder-mined coal in 1914 amounted to 5,498,988 tons, or 35.3 per cent, a marked decrease from the record of 1913, when more than 7,000,000 tons, or almost 40 per cent of the total, was shot off the solid. Hand-mined coal decreased from 6,315,787 tons, or 35.7 per cent. in 1913, to 5,134,787 tons, or 32.9 per cent, in 1914.

The total time lost by strikes in 1914 was 3,940 days, 320 men being idle for an average of 12 days.

About one-half of the coal mined in Alabama in 1914 was washed before being marketed or used in the manufacture of coke. The quantity of washed coal was 7,913,030 tons, yielding 7,081,868 tons of cleaned coal and 831,162 tons of waste.

The statistics of fatal accidents compiled by the Bureau of Mines show that 128 men were killed in the coal-mining operations of Alabama in 1914, all but one underground. Fifty-three of the fatalities were due to falls of roof, 37 to gas explosions and burning gas, 11 to shocks or burns caused by contact with electric wires, and 24 to haulage-way accidents. The death rate per thousand in 1914 was 5.3 against 5 in 1913, and the number of tons mined for each life lost was 121,823, against 142,569 in 1913.

The statistics of production of coal in Alabama in 1913 and 1914, with the distribution of the product for consumption, are shown in the following table:

Production of coal in Alabama in 1913 and 1914, by counties, in short tons.

1913.

County.	Loaded at mines for shipment	Sold to local trade and used by employees	Used at mines for steam and heat	Made into coke at mines	Total quantity	Total value	Average value per ton	Average number of days active	Average number of employees
Bibb	1,802,243	9,214	99,569	....	1,911,026	$2,979,240	$1.56	274	3,158
Blount	174,580	2,758	1,620	....	178,958	236,448	1.32	203	354
Etowah	135,815	725	1,252	....	137,792	171,600	1.25	256	209
Jefferson	7,149,844	83,353	412,891	1,382,746	9,028,834	11,790,737	1.31	266	11,643
St. Clair	861,579	2,909	25,891	....	890,379	1,150,457	1.29	277	798
Shelby	457,313	4,469	35,787	....	497,569	862,783	1.73	257	850
Tuscaloosa	699,690	13,891	68,836	134,888	917,305	1,172,227	1.28	271	1,183
Walker	3,671,708	42,809	101,760	150,986	3,967,263	4,481,373	1.13	223	6,031
Winston	24,841	60	50	....	24,951	36,724	1.47	228	67
Other counties*	116,423	2,162	5,030	....	123,615	200,059	1.62	233	259
Small mines	....	830	....	....	830	2,076	2.50	....	....
Total	15,094,036	163,180	752,686	1,668,620	17,678,522	23,083,724	1.31	255	24,552

*Cullman, Jackson and Marion.

1914.

Bibb	**1,565,660**	**9,180**	**100,006**	....	**1,674,846**	**$2,576,057**	**$1.54**	**242**	**2,986**
Blount	**147,640**	**1,300**	**1,444**	....	**150,384**	**188,235**	**1.25**	**163**	**348**
Etowah	**153,402**	**1,293**	**2,214**	....	**156,909**	**222,239**	**1.42**	**241**	**279**
Jefferson	**6,515,079**	**46,527**	**292,071**	**1,082,468**	**7,936,145**	**10,486,552**	**1.32**	**236**	**11,343**
St. Clair	**726,132**	**1,816**	**24,640**	....	**752,588**	**978,196**	**1.30**	**229**	**896**
Shelby	**467,456**	**3,916**	**27,542**	....	**498,914**	**927,442**	**1.86**	**239**	**936**
Tuscaloosa	**428,387**	**13,355**	**59,562**	**357,595**	**858,899**	**1,177,473**	**1.37**	**226**	**1,491**
Walker	**3,037,567**	**51,284**	**112,704**	**248,630**	**3,450,185**	**4,124,368**	**1.20**	**199**	**5,416**
Winston	**31,035**	**525**	**58**	....	**31,618**	**46,787**	**1.48**	**248**	**101**
Other Counties*	**73,496**	**1,704**	**5,841**	....	**81,041**	**119,496**	**1.47**	**187**	**246**
Small mines	....	**1,893**	....	....	**1,893**	**3,079**	**1.63**	....	....
Total	**13,145,854**	**132,793**	**626,082**	**1,688,693**	**15,593,422**	**20,849,919**	**1.34**	**226**	**24,042**

***Cullman, Jackson, and Marion.**

In the following table is presented a statement of the production of coal in Alabama, by counties, during the last five years, with increase and decrease in 1914 as compared with 1913:

Production of coal in Alabama, 1910-1914, by counties, in short tons.

County.	1910	1911	1912	1913	1914	Increase(+) or decrease (—), 1914.
Bibb	1,580,564	1,633,197	1,781,335	1,911,026	1,674,846	— 236,180
Blount } Cullman	*235,456	*210,070	*276,429	*300,092	*228,146	— 71,946
Etowah	172,465	255,860	171,308	137,792	156,909	+ 19,117
Jefferson	8,298,702	7,776,390	8,174,849	9,028,834	7,936,145	— 1,092,689
St. Clair	428,409	529,211	749,753	890,379	752,588	— 137,791
Shelby	488,141	463,089	496,949	497,569	498,914	+ 1,345
Tuscaloosa	1,081,219	1,031,658	880,967	917,305	858,899	— 58,406
Walker	3,788,479	3,103,595	3,547,962	3,967,263	3,450,185	— 517,078
Winston	16,442	16,424	18,730	24,951	31,618	+ 6,667
Other counties and small mines	21,585	1,927	2,318	3,311	5,172	+ 1,861
Total	16,111,462	15,021,421	16,100,600	17,678,522	15,593,422	— 2,085,100
Total value	$20,236,853	$19,079,949	$20,829,252	$23,083,724	$20,849,919	—$2,233,805

*Includes production of Marion County.

The statistics of production in Alabama from 1840 to the close of 1914 are shown in the following table:

Production of coal in Alabama from 1840 to 1914, in short tons.

Year	Quantity	Year	Quantity	Year	Quantity	Year	Quantity
1840	946	1860	10,200	1880	323,972	1900	8,394,275
1841	1,000	1861	10,000	1881	420,000	1901	9,099,052
1842	1,000	1862	*12,500	1882	896,000	1902	10,354,570
1843	1,200	1863	15,000	1883	1,568,000	1903	11,654,324
1844	1,200	1864	15,000	1884	2,240,000	1904	11,262,046
1845	1,500	1865	12,000	1885	2,492,000	1905	11,866,069
1846	1,500	1866	12,000	1886	1,800,000	1906	13,107,963
1847	2,000	1867	10,000	1887	1,950,000	1907	14,250,454
1848	2,000	1868	10,000	1888	2,900,000	1908	11,604,593
1849	2,500	1869	10,000	1889	3,572,983	1909	13,703,450
1850	2,500	1870	11,000	1890	4,090,409	1910	16,111,462
1851	3,000	1871	15,000	1891	4,759,781	1911	15,021,421
1852	3,000	1872	16,800	1892	5,529,312	1912	16,100,600
1853	4,000	1873	44,800	1893	5,136,935	1913	17,678,522
1854	4,500	1874	50,400	1894	4,397,178	1914	15,593,422
1855	6,000	1875	67,200	1895	5,693,775		
1856	6,800	1876	112,000	1896	5,748,697	Total	270,547,780
1857	8,000	1877	196,000	1897	5,893,770		
1858	8,500	1878	224,000	1898	6,535,283		
1859	9,000	1879	280,000	1899	7,593,416		

The following tables give other details concerning the coal production in Alabama, including rank of the first ten coal producing states; production by classes of mines; labor statistics; strikes and supensions; machines used; methods of mining, etc.

Rank of first ten coal-producing States in 1913 and 1914, with quantity and value of products and percentage of each.

1913.

Production				Value			
Rank	State or Territory	Quantity (short tons)	Percentage of total product'n	Rank	State or Territory	Value	Percentage of total value
1	Pennsylvania:			1	Pennsylvania:		
	Anthracite	91,524,922	16.1		Anthracite	$195,181,127	25.7
	Bituminous	173,781,217	30.5		Bituminous	193,039,806	25.4
2	West Virginia	71,254,136	12.5	2	West Virginia	71,872,165	9.5
3	Illinois	61,618,744	10.8	3	Illinois	70,313,605	9.2
4	Ohio	36,200,527	6.3	4	Ohio	39,948,058	5.3
5	Kentucky	19,616,600	3.4	5	Alabama	23,083,724	3.0
6	Alabama	17,678,522	3.1	6	Kentucky	20,516,749	2.7
7	Indiana	17,165,671	3.0	7	Indiana	19,001,881	2.5
8	Colorado	9,232,510	1.6	8	Colorado	14,035,090	1.8
9	Virginia	8,828,068	1.5	9	Iowa	13,496,710	1.8
10	Iowa	7,525,936	1.3	10	Kansas	12,036,292	1.6

1914.

Rank	State or Territory	Quantity (short tons)	Percentage of total product'n	Rank	State or Territory	Value	Percentage of total value
1	Pennsylvania:			1	Pennsylvania:		
	Anthracite	90,821,507	17.7		Anthracite	$188,181,399	27.6
	Bituminous	147,983,294	28.8		Bituminous	159,006,296	23.3
2	West Virginia	71,707,626	14.0	2	West Virginia	71,391,408	10.5
3	Illinois	57,589,197	11.2	3	Illinois	64,693,529	9.5
4	Kentucky	20,382,763	4.0	4	Ohio	21,250,642	3.1
5	Ohio	18,843,115	4.0	5	Kentucky	20,852,463	3.0
6	Indiana	16,641,132	3.2	6	Alabama	20,849,919	3.0
7	Alabama	15,593,422	3.0	7	Indiana	18,290,923	2.7
8	Colorado	8,170,559	1.6	8	Colorado	13,601,718	2.0
9	Virginia	7,959,585	1.5	9	Iowa	13,364,070	2.0
10	Iowa	7,451,022	1.4	10	Kansas	11,238,258	1.6

Production of coal in Alabama in 1913 and 1914, according to classes of mines, in short tons.

1913.

	Mines		Production		
	Number	Percentage	Total	Average	Per Mine
First Class: (Mines producing over 200,000 tons)	19	8.5	6,112,051	321,687	34.6
Second Class: (Mines producing from 100,000 to 200,000 tons)	42	18.7	5,862,478	139,583	33.2
Third Class: (Mines producing from 50,000 to 100,000 tons)	44	19.6	3,121,545	70,944	17.6
Fourth Class: (Mines producing from 10,000 to 50,000 tons)	94	42.0	2,448,122	26,044	13.8
Fifth Class: (Mines producing less than 10,000 tons)	25	11.2	133,496	5,340	0.8
Total	224	....	17,677,692	78,918	....

1914.

	Mines		Production		
	Number	Percentage	Total	Average	Per Mine
First Class: (Mines producing over 200,000 tons)	15	7.2	4,995,244	333,016	32.1
Second Class: (Mines producing 100,000 to 200,000 tons)	37	17.9	4,851,555	131,123	31.1
Third Class: (Mines producing 50,000 to 100,000 tons)	49	23.7	3,617,972	73,836	23.2
Fourth Class: (Mines producing 10,000 to 50,000 tons)	80	38.7	2,014,766	25,185	12.9
Fifth Class: (Mines producing less than 10,000 tons)	26	12.5	111,992	4,307	.7
Total	207		15,591,529	75,321	

LABOR STATISTICS.

Statistics of labor employed in coal mines of Alabama 1908-1914.

Year	Number of days active	Average Number Employed
1908	222	19,197
1910	249	22,210
1911	227	22,707
1912	245	22,613
1913	255	24,552
1914	226	24,042

Average production per man compared with hours worked per day, and average number of days worked 1910-1914.

Year	8 hours		9 hours		10 hours		All others	Total		Average Tonnage	
	Mines	Men	Mines	Men	Mines	Men	Men	Men	Days Worked	Per Year	Per Day
1910	18	766	36	2,683	184	17,306	1,525	22,280	249	725	2.91
1911	15	550	50	5,345	102	12,628	4,184	22,707	227	662	2.92
1912	11	338	46	4,145	107	13,938	4,192	22,613	245	712	2.91
1913	13	420	36	2,496	135	18,185	3,451	24,552	255	720	2.82
1914	14	646	24	3,546	150	18,115	1,735	24,042	226	648	2.87

Statistics of labor strikes in the coal mines of Alabama in 1913 and 1914.

1913			1914		
Number of men on strike	Total days lost	Average number of days lost per man	Number of men on strike	Total days lost	Average number of days lost per man
1,048	27,041	26	320	3,940	12

MACHINES USED AND METHODS OF MINING.

Number and kind of machines in use in Alabama in 1913 and 1914.

Year	Pick	Chain Breast	Long Wall	Short Wall	Total
1913	249	42	20	66	377
1914	223	31	20	88	362

Bituminous coal mined by machines in Alabama in 1913 and 1914.

Year	Number of machines in use	Number of tons mined by machines	Total tonnage of Alabama	Percentage of total product mined by machines
1913	377	4,124,301	17,678,522	23.3
1914	362	4,937,222	15,593,422	31.66

Quantity and percentage of coal mined by different methods in Alabama in 1913 and 1914, short tons.

Year	Mined by hand	Percentage	Shot off the solid	Percentage	Mined by machines	Percentage	Not reported	Percentage	Total production
1913	6,315,787	35.7	7,052,234	39.9	4,124,301	23.3	186,200	1.1	17,678,522
1914	5,184,787	32.9	5,498,988	35.3	4,937,222	31.7	22,425	.14	15,593,422

COAL WASHING OPERATIONS.

Coal washed at the mines in Alabama in 1913 and 1914, with quantity of washed coal and of refuse obtained from it, short tons.

Year	Quantity of coal washed	Quantity of cleaned coal	Quantity of refuse
1913	8,149,082	7,210,588	938,494
1914	7,913,030	7,081,868	831,162

AVERAGE VALUE OF ALABAMA COAL.

Average value per short ton for coal at the mines in Alabama since 1908.

1908	1909	1910	1911	1912	1913	1914	Advance in 1914
$1.26	$1.19	$1.26	$1.27	$1.29	$1.31	$1.34	$0.03

COKE.

C. E. LESHER.

THE production of coke in Alabama decreased from 3,323,-664 short tons, valued at $9,627,170, in 1913 to 3,084,149 tons, valued at $8,408,443, in 1914. The decrease was 239,515 tons, or 7 per cent, in quantity and $1,218,727, or 12.7 per cent, in value. There were in Alabama 4 retort-oven establishments with a total of 750 ovens, and in 1914 these 4 establishments produced 2,031,535 tons, or nearly 66 per cent of the total output, whereas 16 active beehive plants with an aggregate of 2,562 ovens in blast produced 1,052,614 tons, or a little more than 34 per cent of the total. The average production per oven in the by-product plants was 2,700 tons and the average production from active beehive ovens was 411 tons. The increase in the production of by-product coke in 1914 over 1913 was 8,576 tons, or 0.4 per cent, and the decrease in the production of beehive coke was 248,091 tons, or 18.3 per cent. The value of the by-product coke, however, showed a decrease of $147,117, or 2.8 per cent, a little over 10 per cent of the total decrease in the State. The average yield of coal in coke from the retort ovens was 69.8 per cent, and the average yield in the beehive ovens was 59.5 per cent. There is not the marked difference in the values of retort and beehive cokes (and in favor of the former) in Alabama as is shown in some States, for in Alabama the retort ovens, like the beehive, are located near the mines, and the two in that respect are somewhat on a parity, whereas in most of the States in which retort coke is made the

ovens are at considerable distances from the mines, and the transportation charges assessed against the coal appear in the cost of the coke to the consumer. In fact, the Alabama beehive coke had a higher value per ton in 1914 than the retort coke, the average being $3.16 for beehive and $2.50 for retort coke. The explanation of this seeming inconsistency lies in the fact that all of the retort coke is used by the producers in their own furnaces, and the coke is charged to the furnaces at little more than cost, whereas the greater part of the beehive product is commercial coke, some of it for foundry use, and profits are included in the value.

That the beehive oven has had its day in Alabama and is on the decline is evidenced by the fact that no new ovens of that type have been built in the last five years, and that 18 establishments with a complement of 5,015 ovens out of a total of 34 establishments with 8,535 ovens were idle in 1914, not counting the idle ovens at plants producing some coke in 1914. There were fewer beehive ovens in existence in Alabama in 1914 than in 1908, six years before. The number of retort ovens increased from 620 in 1912 and 700 in 1913 to 750 in 1914. The 750 completed ovens included 300 Semet-Solvay and 450 Koppers ovens. There were no new ovens under construction in Alabama at the close of 1914, and 8 establishments with a total of 1,047 beehive ovens were abandoned during the year.

The production of coke in Alabama in 1880, 1890, 1900, and annually from 1910 to 1914, is shown in the following table:

Statistics of the manufacture of coke in Alabama, 1880-1914.

Year	Establishments	Ovens		Coal used (short tons)	Yield of coal in coke (per cent)	Coke produced (short tons)	Total value of coke at ovens	Value of coke at ovens, per ton
		Built	Building					
1880	4	316	100	106,283	57.0	60,781	$183,063	$3.01
1890	20	4,805	371	1,809,964	59.0	1,072,942	2,589,447	2.41
1900	30	6,529	690	3,582,547	58.9	2,110,837	5,629,423	2.67
1910	43	10,132	340	5,272,822	61.6	3,249,027	9,165,821	2.82
1911	44	10,121	280	4,411,298	62.6	2,761,521	7,593,594	2.75
1912	46	10,208	100	4,585,498	64.9	2,975,489	8,098,412	2.72
1913	46	10,284	20	5,218,323	63.6	3,323,664	9,627,170	2.90
1914	38	*9,285	0	4,678,196	65.9	3,084,149	8,408,443	2.73

*Includes 300 Semet-Solvay and 450 Koppers ovens.

Almost 85 per cent of the coal used in the manufacture of coke in Alabama is washed before being charged into the ovens. In 1914. out of a total of 4,678,196 tons of coal make into coke, 3,974,955 were washed. Of the washed coal used 1,905,317 tons were slack and 2,069,638 were mine run. The unwashed mine-run coal used was 703,241 tons. No unwashed slack was used in 1914.

The character of the coal used in the manufacture of coke in Alabama in 1890, 1900, and for the last five years is shown in the following table:

Character of coal used in the manufacture of coke in Alabama, 1890-1914, in short tons.

Year	Run of Mine		Slack		Total
	Unwashed	Washed	Unwashed	Washed	
1890	1,480,669	0	206,106	123,189	1,809,964
1900	1,729,882	152,077	165,418	1,535,170	3,582,547
1910	771,931	1,308,085	0	3,192,806	5,272,822
1911	693,135	1,295,109	2,937	2,420,117	4,411,298
1912	747,305	896,421	18,793	2,922,979	4,585,498
1913	868,659	684,223	0	3,665,441	5,218,323
1914	703,241	2,069,638	0	1,905,317	4,678,196

Rank of Coke-Producing States.

The record of the production of coke in 1914 effected several changes in relative importance of the States in connection with the industry. Illinois superseded West Virginia as fourth in rank, but with that exception the first seven States held the same position in 1914 as in 1913. Pennsylvania of course stands preeminently first, with Alabama second, and Indiana third. West Virgina was fifth in 1914, but if all of the coke made from West Virginia coal were produced in that State it would be well fixed in second place, as by far the larger part of the coke manufactured in Ohio, Indiana, and Illinois is from West Virginia coal. As, however, the production of coke in retort ovens at or near the points of consumption is likely to continue to increase in greater proportion and the beehive ovens to disappear gradually from the mining

regions, it is not probable that West Virginia will again assume its former importance as a coke-producing State. The quantity of coke made in West Virginia in 1913 was less than one-half of that made from West Virginia coal in ovens outside the State.

Among the less important States Wisconsin moved up from ninth to eighth place, Michigan from eleventh to ninth, Ohio from fourteenth to eleventh, and Tennessee was replaced by Kentucky, which moved from sixteenth to thirteenth place. New York, eighth in rank in 1913, fell to twelfth in 1914. The positions held by the coke-producing States are shown in the following table:

Rank of the States in production of coke, 1910-1914.

State	1910	1911	1912	1913	1914	State	1910	1911	1912	1913	1914
Pennsylvania	1	1	1	1	1	Kentucky	20	19	18	16	13
Alabama	3	2	2	2	2	New Mexico	10	11	12	12	14
Indiana	17	6	3	3	3	Utah	16	17	15	15	15
Illinois	4	4	5	5	4	Tennessee	13	14	14	13	16
West Virginia	2	3	4	4	5	New Jersey	15	16	17	17	17
Virginia	5	7	7	6	6	Minnesota	18	18	19	19	18
Colorado	6	5	6	7	7	Maryland	12	13	16	18	19
Wisconsin	8	9	9	9	8	Washington	19	20	20	20	20
Michigan	11	12	11	11	9	Georgia	21	21	21	21	21
Massachusetts	9	10	10	10	10	Kansas	24	22	22	......	......
Ohio	14	15	13	14	11	Montana	22	......	......	......	......
New York	7	8	8	8	12	Oklahoma	23	......	......	......	......

Comparison of the production and value of coke in Alabama in 1913 and 1914.

	Number of ovens	Coal charged (short tons)	Coke produced (short tons)	Total value of coke at ovens	Percentage of total U. S. value
1913	10,284	5,218,323	3,323,664	$9,627,170	7.46
1914	9,285	4,678,196	3,084,149	8,408,443	9.52
Decrease	999	540,127	239,515	1,218,727	....
Percentage	9.71	10.36	7.2	12.66	....

Quantity and value of coal used in the manufacture of coke in Alabama in 1913 and 1914, and quantity and value of same per ton of coke.

Year	Coal used (short tons)	Total value of coal	Value of coal per ton	Quantity of coal per ton of coke (short tons)	Value of coal to a ton of coke
1913	5,218,323	$7,609,963	$1.46	1.570	$2.292
1914	4,678,196	6,765,639	1.45	1.517	2.200

Character of coal used in the manufacture of coke in Alabama in 1913 and 1914, in short tons.

Year	Run of Mine		Slack		Total			
	Unwashed	Washed	Unwashed	Washed	Unwashed	Percentage	Washed	Percentage
1913	868,659	684,223	0	3,665,441	868,659	16.6	4,349,664	83.4
1914	703,241	2,069,638	0	1,905,317	703,241	15.0	3,974,955	85.0

Statistics of the production of coke in beehive and retort ovens in Alabama, 1913 and 1914.

Year	Beehive Coke		By-product Coke		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1913	1,300,705	$4,401,216	2,022,959	$5,225,954	3,323,664	$9,627,170
1914	1,052,614	3,329,606	2,031,535	5,078,837	3,084,149	8,408,443

Record of by-product ovens in Alabama, 1910-1914.

Year	Built	Building
December 31, 1910	280	340
December 31, 1911	340	280
December 31, 1912	620	100
December 31, 1913	700	20
December 31, 1914	750	0

Complete list of retort coke-oven plants of Alabama, Jan. 1, 1915.

Town	System	Name of company owning plant	Number of installments	Date put in operation	Number of ovens	Uses of coke	Uses of surplus gas
Ensley (near Birmingham)	Semet-Solvay	Tennessee Coal, Iron & R. R. Co.	First	October, 1898	120	Blast furnace	Fuel
			Second	March, 1902	120	Blast furnace	Fuel
Tuscaloosa	Semet-Solvay	Central Iron & Coal Co.	First	February, 1906	40	Blast furnace	Fuel
Tuscaloosa	Semet-Solvay	Central Iron & Coal Co.	Second	1914	20	Blast furnace	Fuel
Woodward	Koppers	Woodward Iron Co.	First	1911	60	Blast furnace	Fuel and power
Woodward	Koppers	Woodward Iron Co.	Second	1913	80	Blast furnace	Fuel and power
Woodward	Koppers	Woodward Iron Co.	Third	1914	30	Blast furnace	Fuel and power
Fairfield	Koppers	Tennessee Coal, Iron & R. R. Co.	First	1912	280	Blast furnace	Fuel and power

GOLD AND SILVER.

J. P. DUNLOP.

THERE does not appear to be any record of the first mining in Alabama, but it probably dates from about 1830 or shortly after the gold excitement commenced in Georgia. The estimated production up to 1879 was $365,300, and the yearly output from 1880 to 1903 varied from $1,000 to $8,000 a year. Alabama, unlike most other Southern States, has made its greatest production in recent years from 1904 to 1910, from deep mines, including the Hog Mountain in Tallapoosa County and the Storey in Talladega County. The estimated total yield of gold from Alabama to the end of 1914 is $749,384.

The mine production of gold in Alabama in 1914 was $11,970, against $11,094 in 1913, and the by-product of silver was 199 fine ounces against 117 ounces in 1913. The total value of the production of precious metals was $12,080, against $11,165 in 1913. No copper, lead, or zinc production has been reported from Alabama in recent years.

The following table shows the mine production of gold, silver, and copper in Alabama since 1905, when the United States Geological Survey first collected detailed figures from the mines of the Eastern States:

Tonnage of ore treated and output of metals in Alabama, 1905-1914.

Year	Ore sold or treated Short tons	Gold*	Silver* Fine ounces	Copper Pounds	Total value
1905	16,425	$41,530	336		$41,733
1906	8,565	24,921	124		25,004
1907	18,400	25,982	439	84,678	43,208
1908	11,174	41,208	282		41,357
1909	9,886	29,239	212		29,349
1910	9,763	33,533	268		33,678
1911	6,360	18,916	171		19,007
1912	5,693	16,724	168		16,827
1913	4,068	11,094	117		11,165
1914	5,079	11,970	199		12,080
Increase in 1914	1,011	876	82		915
Percentage	24.85	7.89	70.08		81.97

*Includes placer gold and silver.

The production for 1914 was mainly from 5,079 short tons of siliceous ore, with an average recoverable value in gold and silver of $2.28 a ton, against 4,068 tons and an average recovery of $2.74 in 1913, and 5,693 tons and an average recovery of $2.96 in 1912. The only placer gold reported was a small quantity obtained by the Clear Creek Gold Mining Co., from the Arbacoochee placers, in Cleburne County. These placers were worked experimentally by means of a small dredge from May until December, when the plant was dismantled.

In Clay County, near Pyriton, are several pyrite mines, all idle in 1913 and 1914, whose ores, formerly sold for their sulphur content, produced residues containing gold, silver and copper. It is reported that the property of the Southern Mineral Development Co. at Pyriton, contains a large deposit of crystalline granular pyrite capable of producing first-class ore for acid manufacture, but that its development awaits a market for the ore. One assay in 1914 is reported to show a content of 5.20 per cent of copper and of $1.60 in gold per ton of the ore.

At the Storey mine, near Waldo, in Talladega County, now owned by the Gold Log Mining Co., a considerable quantity of ore was treated in a 10-ton-5-stamp mill, by amalgamation. The ore is siliceous and occurs in veins and lenses in the metamorphic schists. The mine and the mill were operated intermittently during the year, and considerable development was accomplished.

At the Hog Mountain mine, near Alexander City, in Tallapoosa County, an increased tonnage was treated in a 100-ton cyanidation and blanket-concentration plant, after crushing in rolls and tube mill. Concentrates made contained about 6.2 per cent of bismuth, but this was not paid for by the purchasers. The greater part of the ore treated was unoxidized, but a portion was from the oxidized zone, which extends from 40 to 60 feet from the surface. The veins are of quartz in intrusive granite, and a little pyrrhotite is reported present. The quantity of gold recovered by means of cyanidation was slightly in excess of that derived from concentrates, and most of the small yield of silver was derived from the concentrates shipped.

The old mine of the Dutch Bend Mining Co., also near Alexander City, which is equipped with a 20-stamp mill, was still idle because of litigation.

GRAPHITE.

EDSON S. BASTIN.

THREE firms produced graphite in Alabama in 1914. They were the Quenelda Graphite Company, and the Alabama Graphite Company in Clay County, and the Flaketown Graphite Company in Chilton County.

The last firm installed early in the year a Huff electrostatic separator for the final refining of the flake graphite, with a view especially to the elimination of admixed mica.

According to H. B. Johnson, who installed the electrostatic equipment, the product obtained ran over 94 per cent carbon in carload lots. As this process avoids the use of buhrstone mills, practically no graphite dust is produced, all the product being coarser than 60 mesh. The "dust" brings comparatively small prices, hence the economy effected in this particular is important.

About December 1 a new company, the Jennings Graphite Company, with office at Lineville in Clay County, began the mining of graphite about three miles north of Ashland.

Production and value of crystalline graphite in 1913 and 1914.

	Quantity Pounds	Value	Percentage of total U. S. Quantity	Percentage of total U. S. Value
1913	2,020,910	$87,336	29.73	29.73
1914	2,410,200	118,000	27.79	*36.41
Increase	389,290	31,336		
Percentage	19.26	35.88		

*This is Alabama's proportion of the total U. S. value of graphite (amorphous and crystalline), while Alabama's production in 1914 represents 41.35 per cent of the total U. S. value of crystalline graphite.

For extended notes on the Alabama graphite occurrences, those interested are referred to the section on Graphite by Mr. E. S. Bastin, in Bulletin No. 16 of the Geological Survey of Alabama.—E. A. S.

IRON ORE.

EUGENE A. SMITH.

IRON ores of Alabama in the order of their economic importance are (1) red ore or hematite; (2) the brown ore or limonite; (3) the gray ore. The black band and clay iron stone have been noticed as occurring in a number of places, but only the red ore and the brown ore have been mined on any large scale.

Practically all the ore mined in Alabama is smelted in the State, the shipments out of the State being about equal to those received from other states.

The tables given below will show the rank of Alabama among the States of the Union both in the production of iron ore and in pig iron.

RED ORE OR HEMATITE.

All the ore of this quality mined in Alabama occurs in the Clinton or Red Mountain formation. The Red Mountain ridges occur on each side of the anticlinal valleys which separate the coal fields. In places the red ore ridges are lacking on one side, usually the western, of the valleys, being cut out by faults, while on the other hand the ridge may be duplicated on one side of the valley by the same faults.

In most of the valley occurrences the moderate dips of the ore bed are on the eastern side and there are also practically all of the ore mines. Murphrees Valley makes an exception to this, the moderate dips and the iron mines being on the western side. The iron ore occurs mainly in the central part of the formation in seams or beds one to five in number, which vary in thickness from a few inches to thirty feet.

While the ore seams are very persistent along the outcrop which in Alabama must be as much as 50 miles, yet they vary greatly from place to place, being either too thin or too lean for profitable working in the greater part of this distance.

The most important development of the Clinton ore in this State and in the world is along the 15 or 16 miles stretch of the east Red Mountain between Birmingham and Bessemer, and there is a practically continuous series of mines and strippings for this entire distance. Much mining of this ore has also been done near Gate City, Village Springs, Attalla, Gadsden, Round Mountain, Gaylesville, Ft. Payne, Valley Head, etc.

The completion in October, 1912, of a diamond drill boring in Shades Valley, within a mile of the base of Shades Mountain, gives a definite answer to the speculations concerning the occurrence of red ore under Shades Valley. This boring shows that there is no falling off in the thickness and quality of the ore with distance from the outcrop, and that the depth of the ore below the surface at a distance of more than 2½ miles from the outcrop on Red Mountain is not too great for shaft mining.

The elevation of the surface at the drilling is 595 feet. The top of the ore was reached at a depth of 1,902 feet and a section of the seam in descending order is:

Ore (self-fluxing)	9 ft. 6 in.
Shale	4 in.
Ore (Siliceous)	9 ft. 6 in.

An analysis of an average sample of the drill core of the upper bench, made by David Hancock, shows as follows:

	Per Cent.
Metallic iron	39.51
Silica	9.94
Alumina	3.34
Calcium Carbonate	24.20
Magnesium carbonate	.78
Metallic manganese	.20
Phosphorus	.32

The importance of this demonstration of a vast increase in the amount of red ore available immediately or in the near future, cannot well be overestimated.

In 1913 the Gulf States Steel Company acquired about 1,500 acres of land upon which the drill hole above mentioned was located. They have since been sinking a double track slope to the ore, which they expect to reach about April 1, 1916. In time this is likely to be the largest producing mine in the State.

Another drill hole was put down in Shades Valley in 1913, in Section 19, T. 19, R. 3 W., but the records are not available for publication at the present time.

The hematite production of Alabama for 1914 was 3,902,567 long tons as against 4,370,823 tons, a decrease for 1914 of 468,256 tons or 10.71 per cent.

This 1914 production of hematite is 80.65 per cent of the total iron ore production of the State, and 9.42 per cent of the total iron ore production of the United States.

The average price of hematite in Alabama in 1913 was $1.18; in 1914, $1.21.

Brown Ore or Limonite.

This ore, the second in importance in the State and third in the United States, furnished only 2.26 per cent of the total iron ore production of the United States, and 19.35 per cent of the iron ore production of the State in 1914. The entire limonite production of the United States in 1914 was 1,537,750 long tons, of which Alabama contributed 936,392 tons or 60.89 per cent, and the State holds accordingly the first rank in this industry.

In the early days of iron making and up to the year 1876 this was the only ore used in the catalan forges, bloomaries, and charcoal furnaces of the State. It was then demonstrated that good iron could be made at low cost from the red ores, with coke for the fuel.

In general the limonites are considered the best of the ores of Alabama and they command the highest prices and command a ready sale.

The usual mode of occurrence is in irregular masses of concretionary origin in the residual clays resulting from the decomposition of limestones, and as a consequence the mining is uncertain and expensive. Limonite also occurs in regularly

stratified seams or beds, and then it is the result of the alteration of pyrites or of carbonate ores. Practically all of the brown ore actually mined is that occurring in the residual clays above mentioned. Most of the ore before going to the furnace is washed and screened, and this manipulation, together with the cost of mining, makes it the most expensive of the iron ores, and it is therefore seldom used alone, but is usually mixed with the red ore in proportions determined by the quality of the iron desired. It is used alone in the charcoal furnaces and also in the coke furnaces when a particularly tough pig iron is wanted.

The limonite deposits are very numerous and are distributed over a broad expanse of country and in many places are known to be very extensive. In some of the deposits the ore is in nearly solid mass, in others it is much scattered, and in consequence the amount of foreign material necessary to be moved for every ton of ore produced, varies very much, not only in the different ore banks but also in the different parts of the same bank.

The deposits occur in nearly all the geological formations of the State, but in most of these the ore is either insufficient in quantity or not pure enough to be of much commercial value. The most important of the deposits, in point of extent and value, occur overlying the following formations, viz., the Knox Dolomite and the Weisner Quartzite, the Lauderdale Chert of the Lower Carboniferous, and the Lafayette. Some extensive beds of ore of inferior quality generally occur also in the Tuscaloosa formation of the Cretaceous, and in the upper part of the Lower Carboniferous and in the Metamorphic rocks.

The limonite or brown ore production of Alabama in 1914 was 936,392 long tons, as against 844,917 tons in 1913, an increase of 91,475 tons or 10.83 per cent.

The average price per long ton of brown ore marketed in Alabama in 1913 was $1.61; in 1914, $1.49.

The following tables show details concerning the production of iron ore in the State, together with the rank of the State in mined and marketed iron ore in 1913 and 1914.

Iron ore mined in Alabama in 1913 and 1914, by varieties, with percentage of increase in 1914, in long tons.

Year	Hematite	Brown Ore	Total Quantity	Percentage of total U. S. produc'n.
1913	4,370,823	844,917	5,215,740	8.42
1914	3,902,567	936,392	4,838,959	11.68
Decrease or Increase	— 468,256	+ 91,475	— 376,581	
Percentage of Decrease or Increase in 1914	— 10.71	+ 10.83	— 7.22	

Iron ore marketed in Alabama in 1913 and 1914, by varieties, in long tons.

Year	Hematite	Brown Ore	Total Quantity	Total Value
1913	4,488,176	845,042	5,333,218	$6,648,569
1914	3,589,809	925,117	4,514,926	5,727,619
Increase or Decrease	— 898,367	+ 80,075	— 818,292	— 920,950
Percent. of Incr'se or Decrease	20.02	9.49	15.34	13.85

Rank of first five states in mined and marketed production of iron ore in 1913 and 1914.

1913.

Rank	State	Mined: Quantity (long tons)	Mined: Percentage of total production	Marketed: Quantity (long tons)	Marketed: Percentage of total production	Marketed: Value	Marketed: Percentage of total value
1	Minnesota	38,657,793	62.37	36,603,331	61.37	$80,789,025	61.72
2	Michigan	12,841,093	20.72	12,668,560	21.24	33,479,954	25.58
3	Alabama	5,215,740	8.42	5,333,218	8.94	6,648,569	5.08
4	New York	1,459,628	2.36	1,420,889	2.38	3,100,235	2.37
5	Wisconsin	1,018,272	1.64	896,243	1.50	2,149,397	1.64

1914.

Rank	State	Mined: Quantity (long tons)	Mined: Percentage of total production	Marketed: Quantity (long tons)	Marketed: Percentage of total production	Marketed: Value	Marketed: Percentage of total value
1	Minnesota	21,946,901	52.96	23,298,547	58.66	$40,628,771	56.50
2	Michigan	10,796,200	26.05	8,533,280	21.49	18,722,358	26.04
3	Alabama	4,838,959	11.68	4,514,926	11.37	5,727,619	7.97
4	Wisconsin	886,512	2.13	591,595	1.49	1,178,610	1.64
5	New York	785,377	1.90	640,252	1.61	1,992,892	2.77

PRINCIPAL IRON ORE MINES.

IN 1914 there were 340 iron ore mines active in the United States as compared with 411 in 1913, and 164 mines produced more than 50,000 long tons of iron ore each, as compared with 194 mines in 1913.

The Red Mountain group of red hematite mines in the Birmingham District, Alabama, led in 1914 with an output of 2,008,465 long tons of ore, although this quantity is nearly 200,000 tons lower than the output of this group in 1913. Four of the five mines producing more than 1,000,000 tons each in 1914 are in Minnesota.

Iron ore mines of Alabama that produced more than 50,000 long tons each in 1914.

Name of Mine	Nearest Town	Variety of Ore	Quantity
1. Red Mountain Group	Bessemer	Hematite	2,008,465
2. Woodward, 1, 2, and 3	Lipscomb	Hematite	650,507
3. Raimund No. 1	Bessemer	Hematite	231,363
4. Songo	Songo	Hematite	150,732
5. Steinman	Steinman	Hematite	144,195
6. Greeley	Greeley	Brown Ore	136,289
7. Friedman	Woodstock	Brown Ore	81,556
8. Raimund No. 2	Bessemer	Hematite	77,823
9. Ironaton	Ironaton	Brown Ore	75,245
10. Houston	Rickey	Brown Ore	70,720
11. Docray	Docray	Brown Ore	67,287
12. Attalla	Attalla	Hematite	60,153
13. Tannehill	Goethite	Brown Ore	56,729

Total 13 mines	3,811,014
Unspecified* (4 mines)	861,754
Tonnage from 17 mines producing over 50,000 tons	4,672,768
Tonnage from 14 mines producing less than 50,000 tons each	166,191
Grand total of Alabama production	4,838,959

*Includes the product of 4 mines, producing over 50,000 tons each, operated by 2 companies which do not permit the publication of individual statistics.

PIG IRON.

Quantity and value of pig iron (exclusive of ferro-alloys) marketed in the United States in 1913 and 1914 (first five states), with decrease and percentage of decrease in 1914, in long tons.

State	1913		1914		Decrease in 1914		Percentage of Decrease in 1914	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1 Pennsylvania	12,871,349	$197,726,314	9,267,197	$127,686,331	3,604,152	$70,039,983	28.00	35.42
2 Ohio	6,913,961	103,824,517	5,226,925	70,331,114	1,687,036	33,493,403	24.40	32.26
3 Illinois	2,892,263	45,796,966	1,793,714	24,382,458	1,098,549	21,414,508	37.98	46.76
4 Alabama	1,924,762	23,242,374	1,661,420	17,481,828	263,342	5,760,546	13.68	24.78
5 New York	1,967,449	30,203,678	1,357,575	19,353,309	609,874	10,850,363	31.00	35.92

Production of pig iron, (including ferro-alloys) in 1913 and 1914, (first five States), in long tons
Bureau of Statistics of American Iron & Steel Institute.

State		1913		1914	
	Rank	Quantity	Percentage	Quantity	Percentage
Pennsylvania	1	12,954,936	41.84	9,733,869	41.72
Ohio	2	7,129,525	23.02	5,283,426	22.64
Illinois	3	2,927,832	9.45	1,847,451	7.92
Alabama	4	2,057,911	6.65	1,826,929	7.83
New York and New Jersey	5	2,187,620	7.06	1,559,864	6.69

LIME.

EUGENE A. SMITH.

DURING the year 1914 there was a falling off in the production of lime in Alabama, as compared with the production of the preceding year. The total product of 12 operators in 1914, was 46,966 short tons, a decrease from the 1913 production of 28,502 short tons, or 37.77 per cent. The value of the product was $199,814, a decrease of $90,580, or 31.19 per cent.

As heretofore, the most important use of the lime produced was for building purposes. 22.57 per cent of the State's total production is definitely so credited in the returns, which, added to the 16.61 per cent in the form of hydrated lime, produced by three operators, gives 39.18 per cent definitely assigned to building purposes. Of the 66.29 per cent sold to dealers, uses not specified, a large proportion undoubtedly goes for building purposes, so that probably more than 50 per cent, possibly 75 per cent of the product is thus used. Other chief uses for lime are in chemical works, paper mills, soap factories, manufactories of sand-lime brick, slag cement, etc.

Shelby county as heretofore, was the largest producer in 1914, having produced 28,268 tons, or about 60 per cent of the total. The other producers in the order of their rank were Etowah, Blount, Jackson and DeKalb.

The following tables present some additional data on the lime production in Alabama in 1913 and 1914:

Production of lime, 1913 and 1914.

	Number of operators	Quantity (short tons)	Rank of state by quantity	Value	Rank of state by value	Average price per ton	Percentage of total U. S. value
1913	12	75,468	16	$290,394	16	$3.85	1.98
1914	12	46,966	17	199,814	18	4.25	1.51
Decrease		28,502		90,580			
Percentage		37.77		31.19			

Number of lime kilns in Alabama using various kinds of fuel in 1913 and 1914.

Year	Coal	Wood	Coal and Wood	Total Number of Kilns
1913	18	0	30	48
1914	*16	10	9	35

*8 coal and 8 gas producers.

Those interested in the subject of lime are referred to an article on lime by Ralph W. Stone of the U. S. Geological Survey, and on the Source, Manufacture, and Use of Lime, by E. F. Burchard and Warren E. Emley of the U. S. Geological Survey, published in Vol. II of the Mineral Resources of the United States for the year 1913.

MICA.

MICA mines were opened in Alabama during the early days of mica mining in the Southern States. Prospects have been tested at various subsequent times, and considerable mining has been carried on at intervals during the last 20 years. The mines are located in Randolph, Cleburne, Clay, and Tallapoosa counties, and there are prospects in Lee, Coosa, Chilton and other counties.

The mines of Randolph and Clay counties yield a very fine grade of clear "rum"-colored mica.

MINERAL WATERS.

R. B. Dole.

RETURNS from Alabama indicate that the mineral-water trade in 1914 was much the same as in 1913. The sales amounted to 169,279 gallons, or 408 gallons less than in 1913, and the value of the output was $17,125, or $2,218 less than in 1913. The average price was 10 cents a gallon, against an average of 11 cents in 1913. The decrease in value was principally in table waters. Fourteen springs reported sales; four springs from which no reports were obtained have been considered idle. One spring idle in 1913 was active in 1914, and one spring's output which was not reported was estimated on the basis of sales in 1913. McCary Mineral Well and Talladega Springs reported sales for the first time. Six bathing establishments and 7 resorts accommodating about 1,200 guests were maintained. In addition to the quantity reported as sold, about 86,000 gallons of mineral water was used in the manufacture of soft drinks.

The following 14 springs reported sales:

Bailey Springs, Florence, Lauderdale County.
Bladon Springs, Bladon Springs, Choctaw County.
Bromberg Gulf Coast Lithia Spring, Bayou Labatre, Mobile County.
Cooks Spring, Cooks Spring, St. Clair County.
Dixie Spring, Dixie Spring, Walker County.
Ingram Lithia Well, near Ohatchee, Calhoun County.
Livingston Mineral Well, Livingston, Sumter County.
Luverne Mineral Spring, Luverne, Crenshaw County.
McCary Mineral Well, near Birmingham, Jefferson County.
Matchless Mineral Wells, east of Greenville, Butler County.
Purity Spring, Spring Hill, Mobile County.
Shocco Spring, Talladega, Talladega County.
Talladega Springs, Talladega, Talladega County.
White Sulphur Wells, near Jackson, Clarke County.

The reports of the Alabama Mineral Springs, and The McGregor Spring, were received too late for inclusion in the 1914 tabulations. Estimate on the basis of the 1913 report has been made for the McGregor Spring.

The following table shows the relative productions and their respective values of mineral and table waters, in 1913 and 1914:

Production and value of mineral and table waters sold in 1913 and 1914.

	No. of springs reporting	Quantity sold (gallons)	Average retail price	Total value of mineral waters	Percentage of total U. S. value
1913	15	169,687	0.11	$19,343	0.34
1914	15	169,279	.10	17,125	0.35
Decrease	....	— 408	....	— 2,218	....
Percentage	....	— .24	....	— 11.47	....

The quantity of water used in the manufacture of "soft drinks" in 1913 was 70,000 gallons; in 1914, 86,500 gallons.

NATURAL GAS.

JOHN D. NORTHROP.

THE commercial production of natural gas in Alabama is limited to Madison, Walker, and Fayette counties, in the northern part of the State, the gas produced being supplied to some 395 domestic and 2 industrial consumers in West Huntsville, Jasper, and Fayette. Compared with 1913, the number of consumers supplied with gas in 1914 was increased by 57, and the income derived from the sale of gas was proportionately increased.

In Winston County, also, in the northern part of the State, a small quantity of natural gas produced from a single well was utilized in the field for drilling.

The small gas field in Fayette County is located in the western part of the Warrior coal field and obtains its production from sandstone layers in the lower part of the Pennsylvanian series of the Carboniferous system.

Two productive gas wells were completed in Alabama in 1914 and 4 exhausted wells were abandoned, there being 16 active gas wells in the State at the end of the year.

Because of the small number of producers, the statistics of production and consumption of natural gas in Alabama cannot be given, without revealing confidential data furnished by individual companies.

OCHER.

JAMES M. HILL.

OCHER is a hydrated ferric oxide permeating a clay base. It has a specific gravity of about 3.5 and a decidedly golden-yellow color. As viewed under the microscope and with considerable enlargement the particles composing ocher appear flocculent and uniform. Good grades should contain 20 per cent or more of iron oxide, though there is a wide variation in the iron content of the material sold as ocher. Ferruginous shale is often ground and the product marketed as ocher, but unless the material is actually an ocher, as defined above, such product is classed under slate and shale in this chapter.

In 1913 ocher was produced in Georgia, Pennsylvania, Virginia, Alabama, California, Iowa, and Vermont, the States being named in the order of their producing importance. In 1913 Alabama re-entered the class of ocher producers, a new mine being opened in Clarke County.*

Since the beginning of the European war domestic ochers have been more used than heretofore. It is the general opinion among the users of this pigment that the domestic ocher does not compare with the French ocher in tone, color, or strength. It seems to be the case, as in many American industries, that the producers will not prepare their materials with the care used by the foreign manufacturers. It is the belief of the writer that some domestic ochers could be made equal to the French ochers in every respect if American producers would give more attention to the details of cleaning and floating. It has been said of Americans ochers† that, "by skillful handling, a thoroughly satisfactory color can be obtained. This is done by tinting the ocher with American chrome yellow until the correct shade is obtained."

*This mine was the only producer of ocher in 1914, but there are many promising deposits of ocher in Alabama, especially in the area of the Tuscaloosa formation of the Cretaceous, as well as in other parts of the Coastal Plain southward nearly to the Gulf.—E. A. S.

†Paint, Oil, and Drug Rev., vol. 58, p. 4, Sept. 16, 1914.

SAND AND GRAVEL.

THE total production of sand and gravel in the State in 1914 was 831,430 short tons valued at $262,219, as compared with 1,405,068 tons valued at $398,088 in 1913, a decrease in quantity of 573,638 tons or 40.82 per cent, and in value of $135,869 or 34.13 per cent.

There was a decrease in the quantity of sand of 73,258 short tons or 19.44 per cent, and in value of $2,957 or 2.34 per cent.

In the quantity of gravel there was a decrease of 48.66 per cent, and in the value of 48.94 per cent.

Over 50 per cent of the sand was used for building purposes.

The following tables give a comparison of the production of sand and gravel in 1913 and 1914, and the production, value and disposition of the sand in these two years.

Production in short tons of sand and gravel in 1913 and 1914.

	Sand		Gravel		Total*		Percentage of total U. S. value
	Quantity	Value	Quantity	Value	Quantity	Value	
1913	376,797	$126,483	1,028,271	$271,605	1,405,068	$398,088	1.64
1914	303,539	123,526	527,891	138,693	831,430	262,219	1.10
Decrease	73,258	2,957	500,380	132,912	573,638	135,869	....
Percentage	19.44	2.34	48.66	48.94	40.82	34.13	....

*Chert has been added to these totals.

Production (in short tons), value and kinds of sand in 1913 and 1914.

	Molding Sand		Building Sand		Grinding and Polishing Sand		Fire Sand		Paving Sand		Engine Sand		Other Sand		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1913	57,798	$23,368	288,346	$90,347	25,903	$11,118	....	....	2,750	$1,250	....	....	2,000	$400	376,797	$126,483
1914	92,551	43,702	152,800	51,792	8,052	4,104	22,135	$6,450	5,849	$4,538	12,040	$3,127	10,112	$9,818	303,539	$123,526
Increase or Decr'se	+34,753	+20,334	−135,546	−38,555	−17,851	−7,014	....	....	+3,099	+3,288	....	....	+8,112	+9,418	−73,258	− 2,957
Percentage	60.13	87.02	47.01	42.67	68.91	36.91	....	....	112.69	263.04	....	....	405.60	2353.25	19.44	2.34

STONE.

EUGENE A. SMITH.

ON ACCOUNT of the variety of uses to which stone is put, there is no regular unit of measurement, and the figures in this report represent the values of the different varieties.

PRODUCTION.

Alabama produces only three kinds of stone, viz., limestone. marble, and sandstone.

The total value of the production of stone in Alabama showed an increase in 1914 of 2.63 per cent. The greater part of this increase was in the Limestone (rough building stone, crushed stone for road making, and concrete,) and for agricultural purposes. The sandstone also showed some increase. There was also a notable increase in the value of the marble produced. Exact figures for marble, however, cannot be given except for the year 1914, since before 1914 there were less than three producers.

The following table gives some additional details concerning the total stone production:

Total value of stone (limestone, sandstone and marble) produced in Alabama in 1914. Percentage of total U. S. value, rank of State and number of plants.

Year	Total value	Percentage of total U. S. value	Number of plants	Rank of State
1913	$1,285,944	1.54	35	20
1914	1,319,753	1.71	38	22
Increase 1914	33,809			
Percentage	2.63			

LIMESTONE.

The most important use of the limestone produced in Alabama in 1914 as in 1913 was for furnace flux, while crushed stone for road-making and concrete follow next in importance. A very decided increase in the amount of ground limestone for agricultural purposes, is to be noted.

The limestone burned into lime or used in the manufacture of Portland cement is not taken into account here, but is included in the value of each of the finished products in whose manufacture it was used.

As thus limited the total value of the limestone produced in 1914 was $787,214, as compared with $812,664 in 1913, a decrease of $25,450 or 3.13 per cent.

The value of the limestone produced in 1913 and 1914 classified according to the uses of the stone, are given in the following table:

Value of limestone (not including marble) produced in 1913 and 1914, according to uses.

Use	1913	1914	Increase (+) or Decrease (—)	Percentage
Rough Building	$9,517	$20,992	+ $11,475	+ 119.5
Dressed Building	27,020	20,558	— 6,462	— 23.9
Paving	189	....	....	....
Rubble	188	....	....	....
Riprap	58,850	3,882	— 54,968	— 93.4
Crushed Stone:				
Road making	47,237	75,528	+ 28,291	+ 59.9
R. R. ballast	7,187	1,076	— 6,111	— 85.0
Concrete	168,195	287,119	+ 118,924	+ 70.7
Flux	487,078	360,691	— 126,387	— 25.9
Agricultural	7,208	17,365	+ 10,165	+ 141.1
Total	812,664	787,214	— 25,450	— 3.13

LIMESTONE FOR BUILDING PURPOSES.

The preparation of cut stone for building purposes in Alabama, while on the increase, is not yet what it should be.

Practically all of this material comes from the quarries in the subcarboniferous limestone of the Tennessee Valley, the most important quarries being at Rockwood in Franklin County, operated by Foster-Creighton-Gould Co., of Nashville. This stone is quite similar in appearance, composition, and other qualities to the Indiana stone, and so far as experience in the use of the stone from the two localities in the buildings of the University of Alabama goes, the Alabama stone holds its own under influence of the weather better than does the Indiana stone. Stone steps, door sills, and window sills, buttress caps, etc., of the Alabama stone put in place in 1885 show practically no deterioration in color and wear under foot, and in crumbling and roughening under the influence of the weather, which cannot be said of some portions of the Indiana stone used in buildings erected in 1909-10. The Rockwood quarries have most modern and approved methods of machinery for sawing the stone and handling it in transit to the mills and elsewhere. The stone is of massive formation, of great thickness and extent. Blocks weighing as much as 25 tons, without crack or flaw, are not infrequently quarried, the size of the blocks being practically limited only by the capacity of the hoisting machinery.

The Oolitic variety is most extensively used for building and monumental work. It is of light gray color, uniform grain, and homogeneous texture. It possesses a quality of cheapness, it can be cut to any design required, and is at the same time strong and durable.

With the installing of adequate machinery at the quarry for doing the finished work, there should never be any longer any reason for going outside of the State for this quality of stone. Already the material has been very extensively used in public buildings in Mississippi, Tennessee, as well as in Alabama. The only reason why it was not used in the recently erected buildings at the University of Alabama was that at the time these building contracts were let, the quarries furnished only the rough sawn stone and there was not in Alabama any establishment adequately equipped for the dressing of the stone in the quantity needed.

The above statements are confirmed by a report on the comparative tests made on the Rockwood stone, and those from

Bedford, Ind., and Bowling Green, Ky., by Prof. Robert H. McNeilly, in the Engineering Laboratory of Vanderbilt University.

From this report I give the following extracts:

"GENERAL CHARACTERISTICS.—The Rockwood limestone is an almost pure oolitic limestone with frequent small crystals of calcite distributed throughout its mass. It resembles closely the Bedford stone in appearance, except that it has a slightly more open texture. The Bowling Green stone is finer in grain, softer and more easily pulverized than either the Bedford or Rockwood stones, and contains an appreciable amount of petroleum, which lends somewhat to the ease with which it is worked. In all three stones the texture is exceptionally uniform, as it is almost impossible to detect the bedding planes by eye; however in this respect the Bowling Green stone is most marked, and it is frequently necessary to test by hammer to detect which is the bed plane. Rockwood stone is lighter in color than either the Bedford or Bowling Green stones.

"CHEMICAL ANALYSIS.—The following is an analysis of the Rockwood stone made at my request by Dr. Paul C. Bowers, Chief Chemist of the Tennessee Geological Department:

	Rockwood Stone.
Moisture and loss on heating to 175° C.	0.07
Insoluble siliceous residue (SiO_2, etc.)	0.49
Oxide of Iron and Alumina (Fe_2O_3 & Al_2O_3)	0.30
Carbonate of Lime ($CaCO_3$)	98.23
Carbonate of Magnesia ($MgCO_3$)	0.97
Total	100.06

"PHYSICAL TESTS.—Comparative physical tests of the three samples of stone were made as follows:

Loss in weight on drying,
Cross bending tests,
Compression tests,
Absorption tests,
Per cent of water absorbed.
Specific gravity in bulk, and of pulverized stone,
Density,
Abrasion tests.

The results of these physical tests are summarized in the CONCLUSIONS below quoted.

"CONCLUSIONS.—The above tests were made as nearly as possible, under identical conditions, and barring the accidental characteristics of the samples, which were selected at random, these results are believed to represent truly the comparative characteristics of each of the stones under consideration.

"The Rockwood Stone shows itself to be a superior building stone to the others in every respect except density—but even here, since its absorption of water is the lowest of the three, it should prove more durable, while the smaller weight per cubic foot can be placed more cheaply on account of freight charges.

"As compared with the Bowling Green stone, the Rockwood shows a decidedly higher strength, and characteristics which indicate a greater durability. The Bowling Green stone, however, is undoubtedly more easily worked than either of the other two stones, due to its being softer and also to the presence of oil. This oil has the bad effect of staining the stone itself and the contiguous masonry for several years after it is placed, while the very ease with which the stone can be worked makes the Bowling Green very inferior where used for door sills and steps. This is shown well by the Abrasion Test which shows the Rockwood stone in its best light, as a very superior material for steps, door sills, and other places subject to wear.

"From my examination of these three stones, I believe no builder would make a mistake in using any one of the three, for they are all unquestionably very superior building stones. While each stone may have advantages over the other for some specially desired characteristics, as a building stone for general purposes, each is highly satisfactory.

Respectfully submitted,

ROBERT H. MCNEILLEY,
Assistant Professor of Civil
Engineering, Vanderbilt University."

MARBLE.

The marble of Alabama is of two kinds, crystalline, or true marble, and non-crystalline.

The crystalline or statutary marble occurs mainly in a narrow valley along the western border of the metamorphic area, extending from Marble Valley in Coosa County, through Talladega into Calhoun. The length of the marble belt through

Coosa and Talladega counties is about 50 miles. The width of the valley carrying the marble as a rule is from one quarter to one-half mile, widening in places to a mile and a quarter, for example in the neighborhood of Sylacauga.

The quarries longest known are Gantt's and Herd's near Sylacauga, Nix's near Sycamore, Bowie's near Rendalia, and Taylor's and McKenzie's near Taylor's Mill, east of Talladega. From all of these marble was quarried before the civil war.

During 1914 three companies reported production of marble in Alabama, viz., the Alabama Marble Company at Gantt's Quarry, the Moretti-Harrah Company, whose quarry adjoins that of the Alabama Marble Company at Gantt's, and the Eureka White Marble Quarry near Talladega Springs, but in Coosa County. The other quarries mentioned are in Talladega county, near Sylacauga.

The plant of the Alabama Marble Company at Gantt's Quarry which was completely destroyed by fire in December, 1910, has been rebuilt and equipped with all the machinery needed for the working up of any kind of finished product.

I think it is fairly safe to say that on the whole the marble from this quarry and immediate vicinity is of the highest grade of commercial white marble now on the market and obtainable in large quantity. There are small quantities of marble produced both in Italy and Vermont that are somewhat freer from coloring matter than the best grades that can be produced in Alabama in any quantity. But on the other hand, the poorest grades in Alabama greatly surpass the poorest grades produced elsewhere, so that the average of the Alabama deposit is probably somewhat higher than that of any other so far developed, not excluding even the marble from the Carara district in Italy. The marble from this State (Gantt's Quarry) has now a well established reputation and has been used in more than 200 important buildings throughout the United States.

It can be seen in the galleries of the National Museum in Washington.

The Moretti-Harrah and the Eureka Company furnish the marble in blocks for monumental and rough interior purposes.

A beautiful quality of variegated limestone or marble—red, pink and white—belonging probably to the Cambrian forma-

tion, occurs in Shelby County, a mile or two south of Shelby Springs station on the L. & N. railroad, and extending thence southwest for a mile or two. Nothing but prospecting work has been done on this marble. The Trenton limestone in the Appalachian valleys, particularly Jones Valley below Bessemer, contains marble similar to that quarried in the vicinity of Knoxville, Tenn. Also as to Pratt's ferry on the Cahaba River in Bibb County a quarry was for many years worked in this formation and turned out a very beautiful quality of marble varying in color from gray through pink, red and brown shades.

A black marble which is exceedingly promising, has been reported and some development work done near Anniston, and at Piedmont, Calhoun County, and some very handsome specimens of cave onyx have been obtained from near Kymulga in Talladega County.

In the Coastal Plain the St. Stephen limestone of the Tertiary holds ledges of hard, almost crystalline rock capable of taking good polish. The colors vary from nearly white, through shades of yellowish into red, and it would make a handsome decorative marble, especially for inside work.

Other limestone formations, such as the Subcarboniferous and the Knox Dolomite, could in places be drawn upon for marble.

For the first time in several years as many as three companies have been productive, and the value of the marble produced in 1914 ($370,766) can be revealed.

SANDSTONE.

As may be seen in the tables below, the production of sandstone in 1914 shows an increase in total value of $10,662, or 7.05 per cent as compared with 1913.

In the second table details of the production according to uses cannot be given for 1914, since there are in no instances three or more producers of one kind of stone.

Value of sandstone production in Alabama from 1910 to 1914.

Year	1910	1911	1912	1913	1914
Value	$109,063	$73,195	$27,596	$151,111	$161,773

Value of sandstone production in Alabama in 1913 and 1914, according to uses.

Uses	1913	1914	Increase	Percentage
Rough Building	$37,500			
Ganister				
Rubble	9,055			
Riprap	17,056			
Crushed Stone:—Concrete	87,500			
Total	151,111	$161,773	+ 10,662	7.05

SUMMARY.

BECAUSE of the difference in the units of measurement employed in the various branches of the mineral industry, a summation of the production of the year can include only the values of the products. It is also to be noted that a simple summation of all the values of the minerals or mineral products listed in this pamphlet would give a value much in excess of the true value, since in many cases, as for instance, coal and coke, and iron ore and pig iron and steel, the second product is directly a product of the first, and the value of the first is included in that of the second. To give the values of both as a part of the total would be to repeat, in a measure, at least a partial value of the first or raw product, and would give an erroneous result.

As the Survey has not, however, the figures upon which to base an estimate as to the percentage of each product which was used in the manufacture of some other product, the summation of the mineral production of the State, as given here, will be a simple summation of the values reached by the individual branches of the industry.

According to this rather unsatisfactory manner of summation, which does not include the value of the steel produced, the value of the 1914 raw materials and immediately derived products, was $56,769,559, as compared with $67,530,089 in 1913, a decrease of $10,760,530 or 15.92 per cent.

This production may be classified as follows:

Raw Products	$30,879,288
Pig Iron	17,481,828
Coke	8,408,443
Total	$56,769,559

The more important minerals and products after coal, pig iron and coke, are iron ores, clay products, stone, cement, sand and gravel and lime, given in the order of their relative values.

Below is a tabular presentation of the value of the mineral products of Alabama, as estimated above, for 1911, 1912, 1913, and 1914.

Total value of the mineral production and products in Alabama, in 1911, 1912, 1913, and 1914:

Year.	Value.
1911	$52,772,951
1912	60,141,793
1913	67,530,089
1914	56,769,559

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